6. Conclusions Concerning the Evolution of Close Binaries

The critical rotation of the gainer cannot prevent further mass-exchange.

The presence of predicted inner excretion disks could change the evolutionary scenario of close binaries to a certain degree. As soon as the mass-exchange via the Roche lobe overflow is finished another mass-exchange and/or mass-loss via the excretion disk (or disks) may begin. Unfortunately, we are unable to provide a more detailed prediction now.

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PROPERTIES AND NATURE OF Be AND SHELL STARS

11. A Notable Correlation Between the Long-term Spectral and Photometric Variations of V 1294 Aql (HD 184 279)

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СВОЙСТВА И ХАРАКТЕР ЗВЕЗД Be И ЗВЕЗД С ОБОЛОЧКОЙ

11. *Примечательная корреляция между долговременными спектральными и фотометрическими изменениями V 1294 Aql* (*HD 184279*).

Новые *UBV* измерения V 1294 Aql, полученные в обсерватории Хвар летом 1979, 1980 и 1981 гг., вместе с иными источниками *UBV* фотометрии ясно указывают на наличие корреляции между долговременными фотометрическими изменениями и долговременными спектральными изменениями, обнаруженными Ballereau и Delplace (1981). Во время минимума радиальной скорости объект имеет максималь-

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ную яркость, и наоборот. Это поведение формально подобно тому, что наблюдается для цефеид и очевидно несоответствует модели эллиптического вращающегося кольца. Кроме того, начальное понижение яркости звезды явно связано с возникновением спектра оболочки, подобно Плейоне и 88 Her.

The new *UBV* measurements of V 1294 Aql obtained at the Hvar Observatory in the summers of 1979, 1980 and 1981, combined with other available sources of photometric data clearly show that a strong correlation exists between the long-term photometric variations of the star and the long-term spectral variations recently disclosed by Ballereau and Hubert-Delplace (1981). At minimum radial velocity the object is the brightest, and vice versa. This behaviour is formally similar to what is observed for cepheid variables and apparently disagrees with the idea of an elongated revolving envelope. Moreover, the first brightness decrease of the star is clearly connected with the development of the shell spectrum — similarly as in the case of Pleione and 88 Her.

1. Introduction

V 1294 Aql (HD 184 279, BD + 33° 4065, MWC 319) was announced to be a Be star by Merril et al. (1932). The Hα emission line of intensity 3 (on a scale from 2 to 5) was first observed on an objective-prism spectrogram taken at JD 2 425 804 (July 11, 1929) and, subsequently, confirmed on a slit spectrogram taken at JD 2 425 841 as an emission line of a medium strength. A blue-violet spectrogram obtained on the same day shows shell hydrogen lines, possibly with a very weak Hβ emission, and strong Ca II 1 lines. Merrill and Burwell (1943) suspected the variability of the intensity of the helium lines. On JD 2 427 650 (July 31, 1934) Hα was still a double emission line of moderate intensity with a strong central absorption. Swings and Struve (1943) announced the complete disappearance of the shell lines in the blue-violet region of the spectrum, which they classified as B 3n. Their two spectrograms were obtained on JD 2 430 549 and 51 (July 8 and 10, 1942). Miczaika (1950) reported that also his two spectrograms taken on July 5·91, 1949 and Sept 26.85, 1949 (JD 2 433 103·41 and 33 186·35) only show broad and diffuse H and He lines without any emission. A gradual development of the spectrum from B through Be to the Be-shell phase was observed and described by Hubert-Delplace and Hubert (1979). According to Svolopoulos (1975), a rather strong Hα emission with $V/R \sim 1$ could already be observed on July 12 and 13, 1971 (JD 2 441 144·5 and 145·5).

Plaskett and Pearce (1931) published radial velocities of four Victoria blue-violet spectrograms; three of them were obtained from Aug. 14 to Oct. 9, 1925, and the fourth on June 1, 1927 (JD 2 424 376·753, 390·729, 432·619 and 2 425 032·971). The mean radial velocity was $-2·9 \pm 0·5$ km/s, without any detectable variations. Hydrogen lines are characterized as "abnormally strong and narrow". Merril (1952) describes the variations observed on the nine Mount Wilson spectrograms obtained from Aug. 17, 1929 to Aug. 1, 1951. In 1944–45 the hydrogen radial velocity was around -15 km/s. The H and He lines were strong and narrow in 1929, 1934 and 1945, weak and diffuse in 1943 and 1951, and somewhere between in 1936, 1942 and 1944. Merrill also first called attention to the occasional presence of the shell components in the helium lines. Wilson and Joy (1950) give, without a date, $-15 \pm 3·4$ km/s for V 1294 Aql. This value was obtained as an average of the radial velocities from four spectrograms taken sometime between 1908 and 1949. Petrie and Pearce (1952) published six RV measurements from 1955 and 1958, the average value being -3 km/s. They characterize the lines as very poor and sometimes possibly indicative of a presence of two spectra. Feast et al. (1957) published four radial velocities for the period from July 10.9, 1954 to Sept 9, 1956 (JD 2 434 934·439, 34 992·290, 35 250·603 and 35 730·317). Their mean value is -8 km/s. Also in this case, the lines are described as broad absorptions (He broader than H), without any detectable emission. Ballereau and Hubert-Delplace (1981) reported long-term radial-velocity and line-strength variations which occurred in a wave lasting about 4 years. Their observations refer to the period from 1976 to 1981. The range of RV variations ammounted to almost 200 km/s.

The history of the photoelectric observations of V 1294 Aql is rather amusing. The star was selected as a secondary standard of the UBV system (Johnson, 1955) with the following standard values:

$$V = 6·82^m, \quad B - V = +0·02^m, \quad U - B = -0·83^m.$$

Already in 1958 Lynds (1959) disclosed slight (0·02 to 0·03^m) variability of the star on a time scale of days but this finding had appearently been overlooked by the authors of the Third Edition of the General Catalogue of Variable Stars (Kukarkin et al., 1969) and also by a number of photometric observers who continued to use HD 184 279 as a standard star in various photometric observing programmes. As a result V 1294 Aql became a Be star with one of the best documented long-term photometric behaviours.

Substantial long-term brightness and colour variations of V 1294 Aql (almost $0{\cdot}4^m$ in V, and $0{\cdot}2^m$ in $U - B$) were first reported by Dahn and Guetter (1973) and – apparently independently – by Tempesti and Patriarca (1976) who have "hidden" the star under the name BD + 3° 4065 in their paper. Ballereau and Hubert-Deplace (1981) using the data by Tempesti and Patriarca (1976) and the recent thirteen-colour measurements by Alvarez and Schuster (1981) called attention to a possible correlation between the long-term spectral and photometric variations of V 1294 Aql, but they were unable to demonstrate it in a more quantitative way because of the lack of overlapping photometric and spectral observations.

Very fortunately we have secured UBV observations of V 1294 Aql in the programme of the Be-star

Table 1

Available *UBV* and related photometric data on V 1294 Aql

JD-2 400 000	V	$B-V$	$U-B$	N	Ref.	Notes
15 000::	6·78⁺			1	1	⁺photometric magnitude
27 500::	6·78⁺			1	2	⁺477·0 nm magnitude
34 200:	6·82	0·02	−0·83	1	3	
35 400:	6·82	0·02	−0·81	1	4	
36 435	6·79⁺			14	5	⁺yellow filter, dif. to HR 7438
36 460	6·78⁺			28	5	⁺yellow filter, dif. to HR 7438
37 100:	6·86	0·03	−0·82	1	6	
37 200:	6·83	0·02	−0·85	1	7	
37 800:	6·89	0·03	−0·80		8	
37 900:	6·89	0·05	−0·78		9	
39 960	6·92	0·04		8	10	
40 043	6·91	0·03		3	10	
40 151	6·94	0·03		1	10	
40 414	6·94	0·06		6	10	
40 451	6·99	0·03	−0·73	2	11	dif. to HR 7397
40 453	6·99	0·00	−0·86		16	
40 747	7·08	0·07		4	10	
40 800:	7·10	0·05	−0·71		12	
40 814	7·08	0·06		3	10	
41 143	7·08	0·08		3	10	
41 150:	7·13	0·04	−0·69		12	
41 210:	7·16	0·02	−0·68	4	13	
41 231	7·17	0·02	−0·67	11	13	dif. to HR 7438
41 500:	7·17	0·06	−0·61		12	
41 527	7·19	0·07		3	10	
41 628	7·22	0·10		1	10	
41 863	7·51:	0·06		1	10	
41 917	7·16	0·05		3	10	
42 276	6·99	0·06		1	10	
42 895	6·95⁺			1	14	⁺magnitude V of the Geneva system
42 988	6·97			1	10	
43 006	6·94⁺			1	14	⁺magnitude V of the Geneva system
43 380	6·83⁺			1	15	⁺m_{58} of the thirteen-colour system
43 392	6·86⁺			1	14	⁺magnitude V of the Geneva system
43 690	7·02⁺			1	15	⁺m_{58} of the thirteen-colour system
44 094	7·26	0·02	−0·61	16	17	
44 438	7·22	0·04	−0·64	2	17	
44 812	7·05	0·06	−0·69	27	17	

Column "N" gives the number of measurements forming the mean. The sources of the data specified in column "Ref" are the following: 1 — HD catalogue, 2 — Stebbins et al. (1940), 3 — Johnson and Harris (1954), 4 — Mendoza (1958), 5 — Lynds (1959), 6 — Cousins and Stoy (1963), 7 — Nekrasova et al. (1965), 8 — Johnson and Borgman (1963), 9 — Pfleiderer et al. (1966), 10 — Tempesti and Patriarca (1976), 11 — Haupt and Schroll (1974), 12 — Epps (1972), 13 — Dahn and Guetter (1973), 14 — Burki (1980 — private comm.), 15 — Alvarez and Schuster (1981), 16 — van der Wal et al. (1972), 17 — this paper (Hvar observations 1979—1981).

photometry at the Hvar Observatory in July—August 1979, 1980 and 1981. Thus we attempted to collect all photometric and spectroscopic data about V 1294 Aql available in the astronomical literature. The aim of the present paper is to demonstrate the existence of a correlation among the long-term variations of various physical parameters of V 1294 Aql which may help to discriminate among some of the existing models of the long-term variations of Be stars in this particular case.

2. The Observational Data

The *UBV* measurements of V 1294 Aql have been obtained at the Hvar Observatory during 16 nights in July—August 1979, 2 nights in July—August 1980 and 10 nights in July 3 to 23, 1981. All these measurements were carried out differentially using 35 Aql (HD 183 324; $V = 5{\cdot}80^m$, $B - V = +0{\cdot}08^m$, $U - B = +0{\cdot}07^m$) as the primary comparison star. Another Be variable, V 923 Aql has also been measured simultaneously in these measurements, as well as two check stars, HD 183 227 and HD 184 663. Thus, there is no doubt that the variations observed can be attributed to V 1294 Aql and not to the comparison star. All the data were transformed to the international *UBV* system and corrected for differential extinction through frequent measurements of standard stars.

Slight photometric variations of V 1294 Aql (several hundreds of magnitude), occurring on a time scale of days, are clearly visible in our data. We do not publish the detailed data here because they will be published in another paper dealing with the behaviour of the star on a time scale of days and weeks.

In Tab. 1 we have compiled all the *UBV* measurements of V 1294 Aql available in the astronomical literature and known to us. Thanks to the fact that the $B - V$ index of the star has always been close to zero, it was possible to include also some other magnitude determinations obtained in various other photometric systems to characterize the changes of the V magnitude of the star. We have also compiled all available radial-velocity data and records of the spectral variations of the star. One of us (P. H.) measured the radial velocities of various lines on a coudé spectrogram from the Victoria 48-inch telescope (dispersion 0·6 nm/mm) obtained by Dr. J. Grygar on HJD 2 440 788·904, with the following results: H I (22 lines) $-1{\cdot}7 \pm 1{\cdot}1$ km/s, He I (3 lines) $-5{\cdot}8 \pm 2{\cdot}9$ km/s and Ca II 1 (2 lines) $-7{\cdot}4 \pm 0{\cdot}00$ km/s. The inspection of two existing Ondřejov red spectrograms of V 1294 Aql shows that the Hα line was a double emission with $V \gg R$ on JD 2 443 743·33,

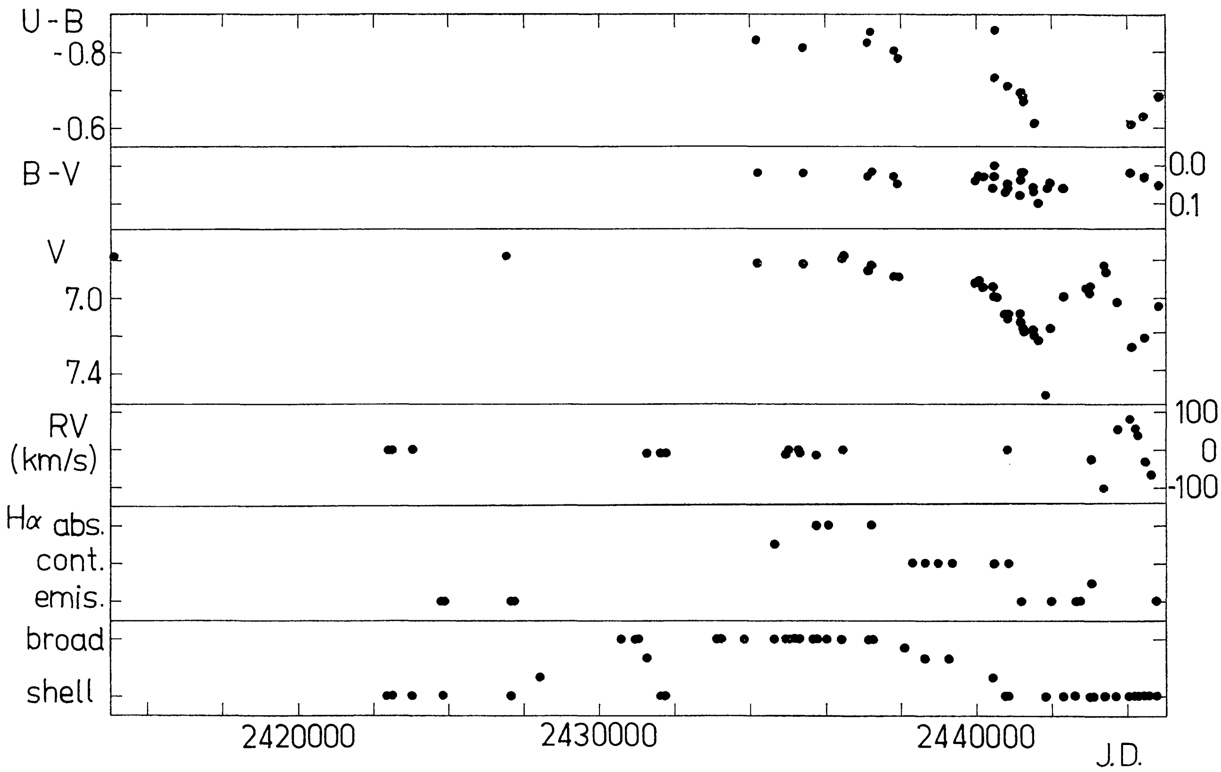

Fig. 1. Long-term spectral and photometric variation of V 1294 Aql. Appearance and disappearance of the shell lines is shown on the lowest panel.

and with $V \ll R$ in JD 2 444 854·32. Even on this latest plate, the He I lines appear as narrow shell features.

3. Discussion of the Results

A plot of various parameters characterizing the long-term variations of V 1294 Aql is shown in Fig. 1. The following basic conclusions can be drawn from the available observational data:

1. The large and possibly cyclic RV variations of the shell lines including the Ca II lines of V 1294 Aql, reported by Ballereau and Hubert-Delplace (1981), began after the spectrum of the star developed from B to Be and probably at the moment when a fully developed shell spectrum of H I, He I, Fe II, Fe III, Mg II, Si II, Ni II and Ca II appeared.

2. The recent transition of the spectrum from B to Be shell phase was clearly accompanied by a substantial decrease of the brightness and by the reddening of the object. As soon as the shell spectrum was fully developed, the brightness started to vary in phase with the RV variations, and in the sense that the object was *the brightest* at *minimum* radial velocity and vice versa. At the moment, no firm conclusions can be made as to the presence of colour changes during the period of the RV variations because of lack of the data.

3. Old *RV* and magnitude data are unfortunately too scarce to allow us to decide whether previous shell phases of V 1294 Aql (prior to 1934 and in 1945) were also accompanied by large RV and light variations.

4. It is important to stress that, according to Ballereau and Hubert-Delplace, the equivalent widths of the spectral lines (not shown in Fig. 1) also vary in phase with the RV and light variations in the sense that the lines are the strongest at maximum velocity, i.e. at minimum light.

5. The available, very scarce data seem to indicate that the V/R ratio of the Hα line varied in phase with the radial-velocity curve, similarly as for other known long-term V/R variables.

How to interpret these observations? Ballereau and Hubert-Delplace (1981) made a direct analogy between the variations of V 1294 Aql and the long-term variations observed for ξ Tau and 48 Lib. In light of the new facts, such a view can hardly be accepted. Recent study by Itoh et al. (1981) clearly indicates that during the first 7-year cycle of RV and spectral variations of ξ Tau, the maximum equivalent widths of spectral lines were observed quarter of a period *after* the maximum velocity. Itoh et al. had shown that this and most of the other pieces of evidence agree with the model of an elongated revolving disk for the envelope of ξ Tau, which was originally suggested for this star by Kříž and Harmanec (1975). In contrast to it, the relative behaviour of the observed physical parameters during the recent 4-year cycle of V 1294 Aql is different and clearly contradicts the model of an elongated revolving envelope. In the case of such an envelope one would expect that – if some detectable light changes should occur – their extrema would correspond to those instants when we observe the envelope along the line of apsides. However, the extrema in radial velocity should occur quarter of a period sooner and later, which, apparently, is not the case of V 1294 Aql.

Formally, the relative behaviour of the radial velocity and the light is the same for V 1294 Aql as for the cepheids and δ Scuti variables. This may speak in favour of the hypothesis that the envelope of the star is undergoing some kind of pulsation. However, before accepting such a conclusion, we have to explain the following facts:

1. Current models of pulsating stars interpret the observed dependence between the light and velocity curves (maximum RV at minimum light) by the fact that the layers producing continuous radiation pulsate with a phase shift with respect to those in which the observed spectral lines are formed. In the case of an extended envelope one would expect, therefore, this phase shift be detectable from RV curves of various ions characterizing motions of the inner and outer parts of the envelope. However, according to Ballereau and Hubert-Delplace, radial-velocity curves of *all* ions, including such extremes as Fe III and Ca II, are similar to each other.

2. The pulsational period of 4 years is very long. It should be verified whether Baade's (1979) idea of non-radial pulsation with the wave travelling against the sense of the rotation is applicable to this case.

Observationally, it would be interesting to measure the radial velocity of the Hβ emission on the wings of the line. It is known (cf. McLaughlin, 1961) that for those V/R and RV Be variables, which can be interpreted by the elongated revolving disk model, the radial velocity of hydrogen emission lines (with the exception of the Hα line) follow the RV curve similar to the RV curve of the shell lines.

As to the light variations of V 1294 Aql themselves, one can see a remarkable similarity to the light variations of Pleione (28 BU Tau; Sharov and Lyuty, 1976) and possibly also of 88 Her (Harmanec et al., 1978, paper 8 of this series) – see Fig. 2. In all three

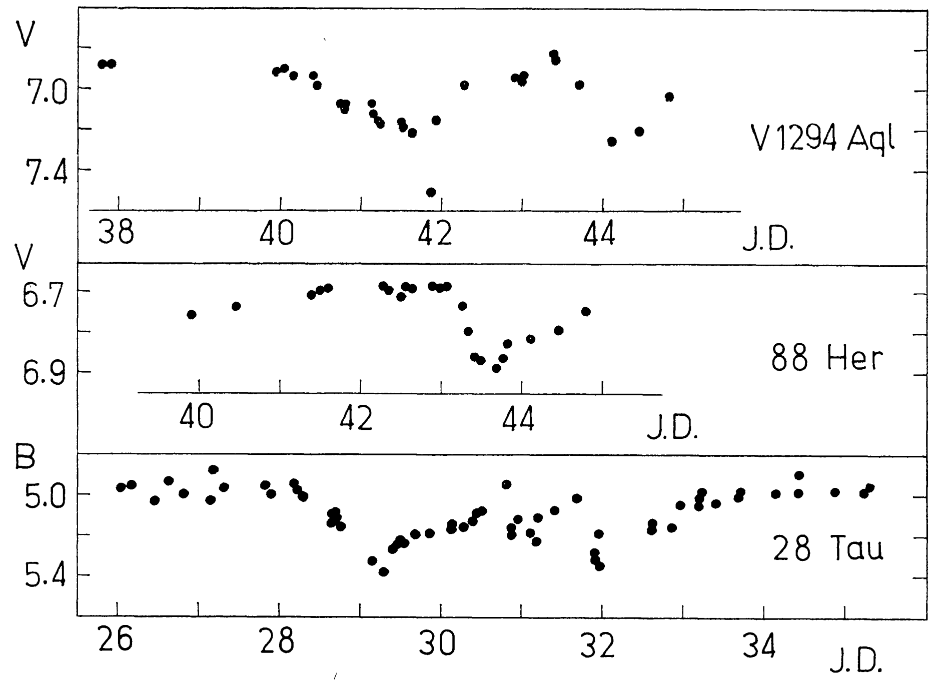

Fig. 2. Comparison of the long-term photometric variations of V 1294 Aql, 88 Her and BU Tau. Julian dates are given in units of thousands of days with 24 00 000 subtracted.

cases, the development of the shell spectrum was accompanied by a gradual brightness decrease which was followed by a brightness increase after the shell spectrum was fully developed. In the case of Pleione, another light minimum followed on the light curve, similarly as for V 1294 Aql. However no large RV variations were observed for Pleione during its shell phase. Clearly we cannot go further with this analogy at the moment. It is unclear whether the light and velocity variations of V 1294 Aql will continue in the future or whether they will decay after one cycle. On the other hand, one cannot exclude the possibility that 88 Her will soon begin to exhibit long-term RV variations similar to V 1294 Aql.

No doubt the continuing observations of all three stars are highly desirable. We thus appeal to both, theoreticians and observers, interested in the problems of Be stars, to concentrate their efforts on understanding this enigmatic object. In addition to continuing new observations it would also be very important to investigate old spectrograms of V 1294 Aql possibly existing in some plate files and to confirm or disprove the suspicion that the brightness and RV variations occurred only during the latest recorded shell phase of the object.

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SEARCH FOR RAPID VARIABILITY OF 53 Cam

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ПОИСКИ БЫСТРОЙ ПЕРЕМЕННОСТИ 53 Cam

Фотоэлектрические наблюдения магнитной пекулярной А звезды 53 Сам, которые мы получили в обсерватории Скальнате Плесо в 1978 и 1979 гг, анализируются с точки зрения быстрой переменности. Наблюдения были выполнены со среднеполосным фильтром с эффективной длиной волны 526 нм. Кроме разностей $m_{53\mathrm{Cam}} - m_{\mathrm{Comp}}$ мы исследовали тоже поведение отклонений звезды сравнения в течение наблюдения. Была найдена сильная корреляция между поведением переменной звезды и звезды сравнения. Характер обеих кривых отличается в отдельные ночи и зависит от атмосферных условий. Каждый наблюдавшийся ход подробно анализируется и делается вывод, что все изменения, которые мы наблюдали на кривой блеска 53 Cam только видимые и являются результатом атмосферной экстинкции над местом наблюдения.

Photoelectric observations of a magnetic Ap star 53 Cam made at the Skalnaté Pleso Observatory in 1978 and 1979 are analysed from the point of view of rapid variability. The observations were made with an intermediate passband filter, effective wavelength 526 nm. Besides the differences $m_{53\mathrm{Cam}}-m_{\mathrm{Comp}}$, we also investigated the behaviour of the deflections for the comparison star during the observation runs. A strong correlation between the behaviour of the comparison and variable star light curve was found and the appearence differs from night to night depending on atmospheric conditions. Each observation run is analysed in detail and it was concluded that all observed variations are only apparent and due to the variability of atmospheric extinction above the observation site.

1. Introduction

The magnetic and photometric variable Ap star 53 Cam (HR 3109, HD 65 339) became suspect of rapid variability as a result of spectroscopic observations (Polosukhina, 1977, 1980). This stimulated the international co-operation in observing some magnetic stars. The first preliminary results of this co-operation were reported at the time of the 4th Conference of the Subcommission „Magnetic Stars" of the Multilateral Co-operation of the Academies of Sciences „Physics and Evolution of Stars" held at SAO, Zelenchukskaya, USSR in October 1980. Apart from other things, photometric variations of tens of minutes duıation were found. In this paper we shall discuss 53 Cam observations made at our observatory in the years 1978–1979.

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