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ASTRONOMY AND ASTROPHYSICS

Light variations of massive stars (α Cyg variables)*

XV. The LMC supergiants R 99 (LBV), R 103, R 123 (LBV) and R 128

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Abstract. $VBLUW$ photometry (Walraven system) of the four variable LMC supergiants R 99, R 103, R 123 and R 128 is analysed, searched for periods and discussed. Based on former and present photometry we conclude that two of the three emission-line objects are undoubtedly active LBVs (R 99 and R 123), although not so spectacular. R 123, like AG Car near minimum brightness, shows a low amplitude S Dor activity with superimposed α Cyg-type variations.

Key words: stars: variables: other – supergiants – stars: individual R 99 = HDE 269445, R 103 = HDE 269546 = -68 82, R 123 = HD 37836 = -69 201 = S 124, R 128 = HDE 269859 = -69 221

1. Introduction

A photometric survey investigating the optical instability of massive stars has led to the publication of a series of papers by the first author during the last 13 years. These studies are largely based on the $VBLUW$ photometric system of Walraven. All evolved massive stars are photometric micro variables also called α Cygni variables. Amplitudes and time scales amount to $\lesssim$ $0\overset{\mathrm{m}}{.}2$ and days to months, respectively. Non-radial (e.g. Lovey et al. 1984; Gautschy 1992; Balona 1992) as well as radial pulsations (Cox et al. 1995) have been suggested as possible causes.

A small subgroup consists of the hot S Dor variables or luminous blue variables (LBVs), which in or near minimum brightness show the same type of microvariations (for a review, see Sterken 1989), called α Cyg-type variations, usually on a time-scale of 2–6 weeks, depending on the phase of the S Dor-activity (van Genderen et al. 1997a): halfway up to maximum light another type of microvariations emerges rather abruptly: the so-called 100 d-type variations (van Genderen et al. 1997b).

Often the photometric oscillations are not strictly periodic, but differ from cycle to cycle (e.g. Balona 1992). Therefore, one often speaks of quasi- or pseudo-periods. The resulting phase diagrams always display considerable scatter (van Genderen 1991; van Genderen et al. 1992).

The cause of the quasi-regularity can be partly attributed to stochastic processes, such as large-scale atmospheric motion fields (e.g. de Jager et al. 1984; Burki 1987; van Genderen 1991), disturbing a regular pattern of stellar oscillations. The discovery that the dormant LBV ζ^1 Sco is a multi-periodic variable (Sterken et al. 1997), and that the LBV R 40 (= HD 6884) is at least multi-cyclic if not multi-periodic (Sterken et al. 1998), can be considered as a breakthrough in understanding the complex variability of super- and hypergiants. Independently, Kaufer et al. (1997) found the same phenomenon in a study based on spectroscopic monitoring of BA-type supergiants like HD 92207 and HD 96919. Perhaps all α Cyg variables are more or less subject to multi-periodicity with an additional intrinsic noise component (e.g. Sterken et al. 1997).

One of the aims of the photometric survey was to investigate the distribution of the quasi-periods in the upper region of the HR-diagram. Earlier attempts to define a semi-empirical $PLT_{\rm eff}$ relationship have been undertaken by Burki (1978) and by Maeder (1980). So far, additional variables, especially LBVs in or near minimum brightness, have been found to fit reasonably well into that relationship (e.g. van Genderen & Sterken 1996). However, since we found that the period changes during the S Dor activity, that individual cases show multi-periodicity, and that the latter could be true for all members of this class, we are facing a dilemma: which period should be taken to plot the object in the grid of 'P = constant' lines? Thus, it is likely that the semi-empirical $PLT_{\rm eff}$ relationship is influenced by a mix of selection effects so that its application should be considered with more reserve.

In the present paper we discuss $VBLUW$ photometry of four new variables in the LMC, of which three are emission-line objects and two are LBVs. Light and colour curves are analysed and searched for periods.

2. Observations and reductions

The photometry of the four programme stars was obtained with the 90-cm Dutch telescope equipped with the simultaneous Walraven $VBLUW$ photometer, at ESO in Chile, between 1988 and

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Table 1. Aperture used (Ap, in arcseconds) and the mean error (in units of 0.001 log intensity) for the comparison star and the four programme stars.

Star	Ap	V	$V-B$	$B-U$	$U-W$	$B-L$
HD 33486		5	2	3	2	3
R 99	23	2	2	2	5	2
R 103	16	2	1	2	2	2
R 123	23	2	1	2	3	1
R 128	16	3	2	2	3	2

1991. Observations were made for R 99 from 1989 to 1991, for R 103 and R 123 from 1988 to 1991 and for R 128 from 1987 to 1990, with for the latter also a few observations in 1983, 1986 and 1987.

A description and the aim of the monitoring programme, the observational technique and the achieved accuracy – with mean errors (m.e. = $\sigma/\sqrt{n}$) in the order of $\pm$ $0^{\rm m}_{.}002$ for the average of the nightly means relative to the comparison star – can be found in van Genderen et al. (1985). The effective wavelengths and the band widths are given by de Ruyter & Lub (1986). The Balmer limit is located in the L band, the U band lies at the short wavelength side of the Balmer jump, the W band lies in the Balmer continuum. The photometric data in the $VBLUW$ system are given in log intensity scale.

V and $V-B$ can be transformed in the equivalent values of the UBV system (V_J and $(B-V)_J$) by formulae given by Pel (1987); see also van Genderen et al. (1992).

Table 1 lists the programme stars, the aperture used and average standard deviation (σ) per datapoint relative to the common comparison star HD 33486 (B9, $7^{\rm m}_{.}9$), all in log intensity scale. Average mean errors are of course smaller, in these cases by about a factor two to three.

Table 2 lists the photometric results for the comparison star and the four programme stars. The differential intensities and colours relative to the comparison star are listed in Table 3, to be published, together with data for other LBVs, in a forthcoming article in The Journal of Astronomical Data.

3. The light- and colour curves, the period analysis

3.1. *R 99 = HDE 269445*, Ofpe/WN9

R 99 was found to be variable with a total range of $0^{\rm m}_{.}15$, which is abnormally large for such an early spectral type (see Fig. 13 in van Genderen et al. 1992). Fig. 1 shows an example of the light and colour curves (in log intensity scale) as a function of Julian Date during two months in 1990. Sometimes a W measurement is missing because of a bad reading. The error bars represent twice the mean error per datapoint.

The time scale of the variations lies between 2 and 10 d (see below). Stahl et al. (1984) found light variations of $\sim$ $0^{\rm m}_{.}1$ within two weeks of monitoring. The large range in the colours is peculiar: about 40% of the range in V (Fig. 1), compare with R 103 (Fig. 7), R 123 (Fig. 11) and R 128 (Fig. 12).

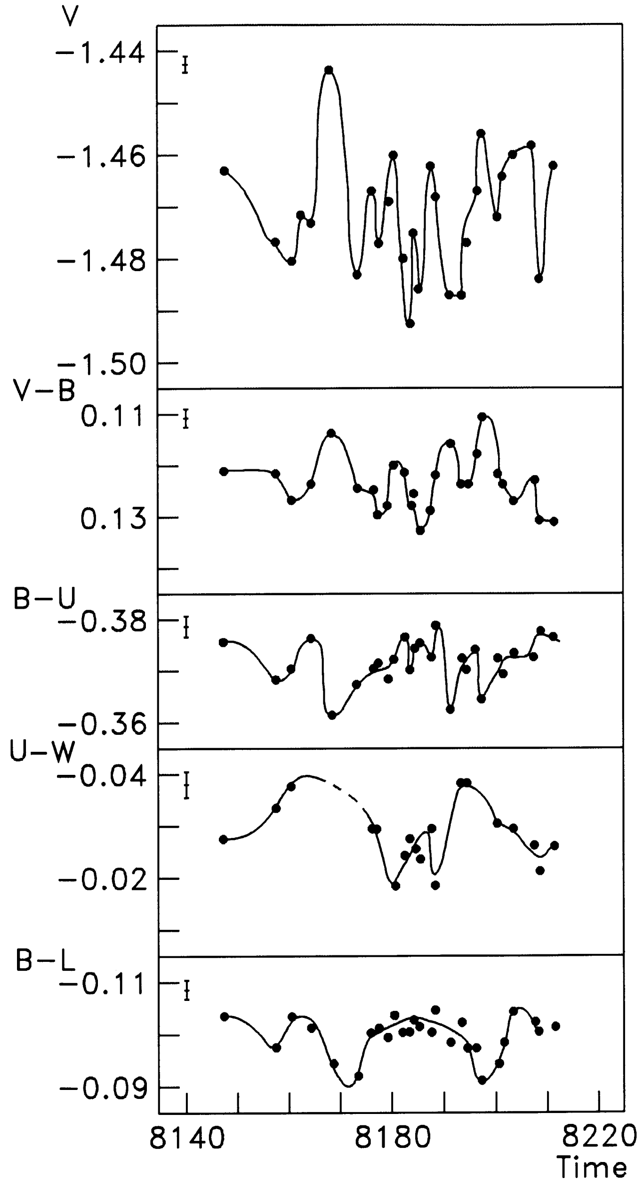

Fig. 1. A portion of the light and colour curves of R 99 relative to the comparison star in log intensity scale as a function of JD - 2440000. Bright and blue are up. Error bars are twice the mean error.

Like most α Cyg variables, the brightness amplitude of R 99 in general show a progressive increase to shorter wavelengths. However, there are exceptions: simultaneous with the peaks in V and $V-B$, there are dips in $B-U$ and $B-L$, e.g. around JD 244 8170 and JD 244 8197. Thus, light ranges in L and U are significantly smaller than in B. More quantitative and qualitative information can be obtained by combining this inspection with two–colour diagrams. Fig. 2 shows two of these as an example (with blue up and to the right). In the upper diagram B and W are compared to U. When $B-U$ is blue, $U-W$ is red, thus, W often has a smaller range than U. However, this is not always the case (which can also be identified in the colour curves) considering the relatively large scatter and the small slope of the regression line.

Table 2. The average photometric parameters of the common comparison star and of the four programme stars (in log intensity scale for the $VBLUW$ system and in magnitudes for the transformed UBV parameters (with subscript J). N is the number of measurements.

		Sp	V	$V-B$	$B-U$	$U-W$	$B-L$	V_J	$(B-V)_J$	N
	HD 33486	B9	-0.390	-0.010	0.330	0.078	0.112	7.86	-0.04	
R 99	HDE 269445	Ofpe/WN9[1]	-1.865	0.116	-0.045	0.057	0.008	11.54	0.28	88
R 103	HDE 269546	B3 Ip[2]	-1.215	0.008	-0.009	0.026	-0.010	9.92	0.01	64
R 123	HD 37836	Bpec[2]	-1.490	0.061	-0.069	0.029	-0.009	10.61	0.14	117
R 128	HDE 269859	B2 Ia[3]	-1.480	-0.007	-0.038	0.008	-0.022	10.59	-0.03	85

Notes to Table 2:
[1] Walborn (1982); Bohannan & Walborn (1989)
[2] Feast et al. (1960)
[3] Walborn et al. (1991)

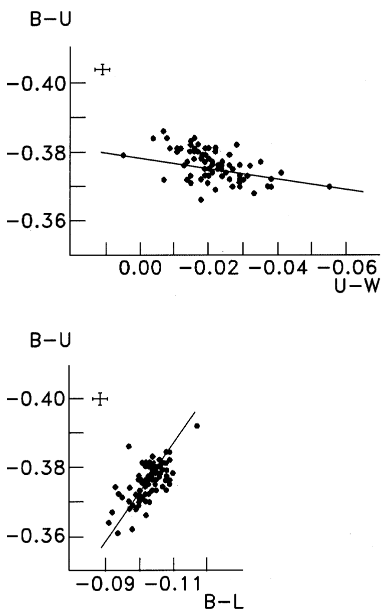

Fig. 2. Two–colour diagrams of R 99. Blue is up and to the right. Error bars are twice the mean error.

Table 3. *(available electronically in a forthcoming article of The Journal of Astronomical data)* Differential brightness and colours in the $VBLUW$ system of R 99, R 103, R 123 and R 128 relatively to the common comparison star in log intensity scale.

In the lower diagram L and U ranges are compared to B. The regression line indicates that the L and U ranges are more or less equal. Whether they are larger or smaller than B ranges can be deduced when combined with diagrams including V and $V-B$.

Fig. 3 shows that the star also exhibits brightness variations of $0\overset{\mathrm{m}}{.}3$ on a long time-scale as evidenced by magnitudes (V_J) and colours $(B-V)_J$ collected from the literature by Stahl et al. (1984) and by Stahl & Wolf (1987) and completed with those of the present paper. The time-scale is of the order of 30 y and the colour becomes red in the maximum suggesting an S Dor phase (mainly caused by a temporary expansion of the stellar radius and a decrease of the temperature, and sometimes also partly by an increase of the stellar-wind density). More specifically, Fig. 3 suggests that R 99 exhibits a VLT-SD (Very Long-Term S Dor) cycle. This is one of the two types of SD phases identified by van Genderen et al. (1997a, b). Thus, the suggestion by Stahl et al. (1984) that R 99 and Ofpe/WN9 stars in general (e.g. Pasquali et al. 1997a, b) are related to LBVs is reinforced. We consider R 99 a real LBV, but subject to one type of SD phase only and, because of the low amplitude, not very spectacular.

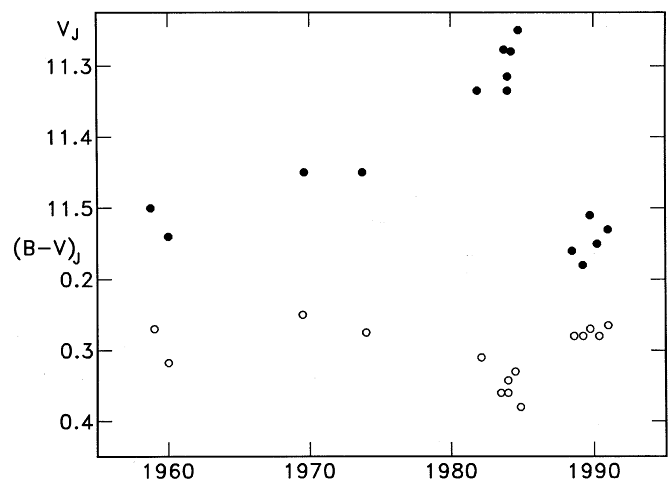

Fig. 3. The long time-scale light and colour variation of R 99 representing a VLT-SD cycle.

A period search was carried out using Fourier analysis of the V and B data in the frequency range 0.08–0.5 cycles per day (cd^{-1}), and the resulting amplitude spectrum and spectral window for V are given in Fig. 4. The strongest amplitude occurs at 0.479 cd^{-1}($P = 2.088$ d), with nearby 1 cycle per year aliases. Another strong amplitude is at 0.1003 cd^{-1}($P = 9.98$ d)

Fig. 5 shows, for the 2.088 d period, the light and colour curves $V-B$ and $B-L$ (showing a clear cyclic behaviour). The other periods near 2 d show some more scatter. Note the difference in position of the maxima in $V-B$ and $B-L$. A weak cyclicity in $B-U$ is present, but with a larger (intrinsic) scatter than in $B-L$. No cyclicity is present in $U-W$ when folded with the periods around 2 d because of an intrinsic scatter three times larger than in the other colours. This points to an

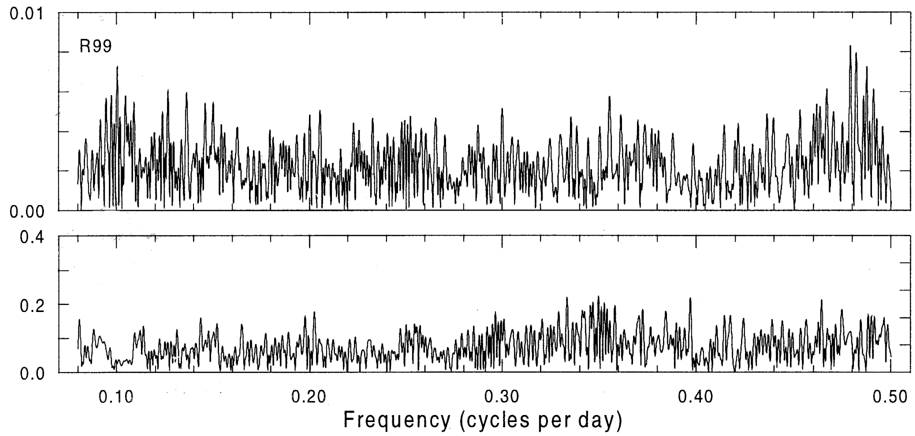

Fig. 4. Amplitude spectrum (top) and spectral window (bottom) for V measurements of R 99.

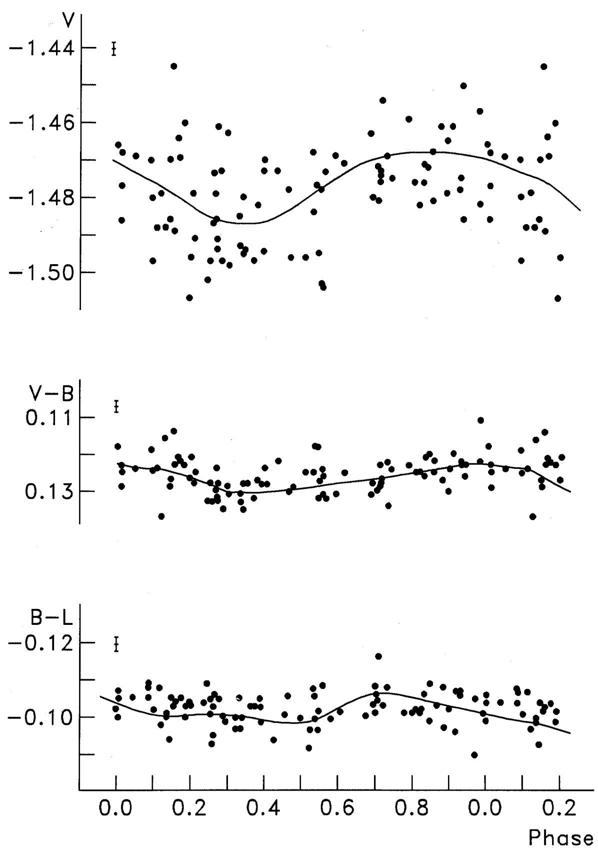

Fig. 5. The phase diagrams of R 99 folded with P = 2.088 d. Bright and blue are up. Error bars are twice the mean error.

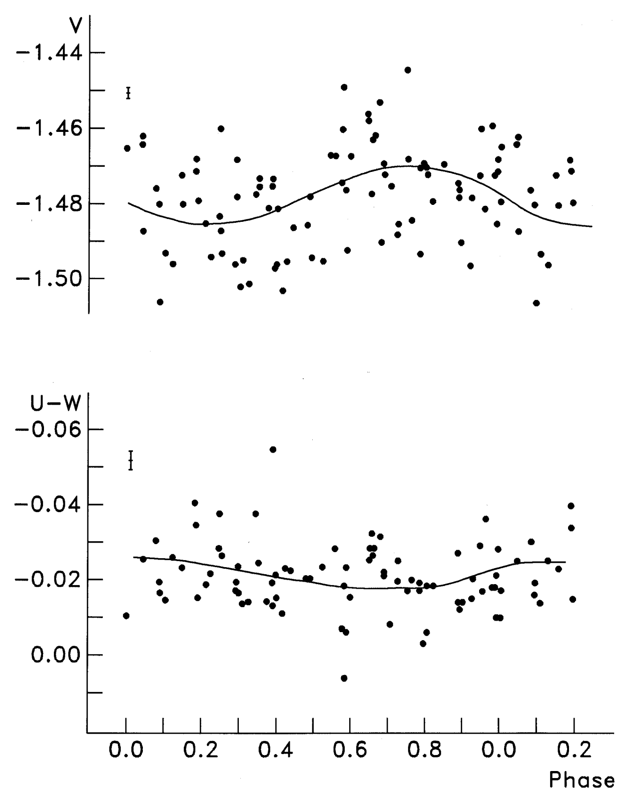

Fig. 6. The phase diagrams of R 99 folded with P = 9.98 d. Bright and blue are up. Error bars are twice the mean error.

additional variability in the W passband independent from the 2.088 d period.

The phase diagram for the 9.98 d period shows no cyclic behaviour in the colours whatsoever with the exception of $U-W$, which is a most surprising result (Fig. 6). Furthermore, this colour runs in antiphase with V which means that on those occasions when W has a smaller range than U (see discussion on Fig. 2) it is modulated by a 9.98 d period.

Considering R 99's pure emission-line spectrum in the optical region (Walborn 1982; Bohannan & Walborn 1989), Stahl et al. (1984) suggested that it has a luminous disk. It is possible that the modulation has something to do with variations in the physics of a disk, but a second stellar pulsation mode is also a possibility.

3.2. R 103 = HDE 269546 = -68 82, B3 Ip

R 103 appears to be variable with a maximum light range of $0\overset{\text{m}}{.}16$, which is rather high compared with α Cyg variables of the same spectral type (see Fig. 13 in van Genderen et al. 1992). There are no firm indications that R 103 is variable on a long time-scale (Thackeray 1974). The photometric data obtained by Walraven & Walraven (1977) made somewhere between 1958

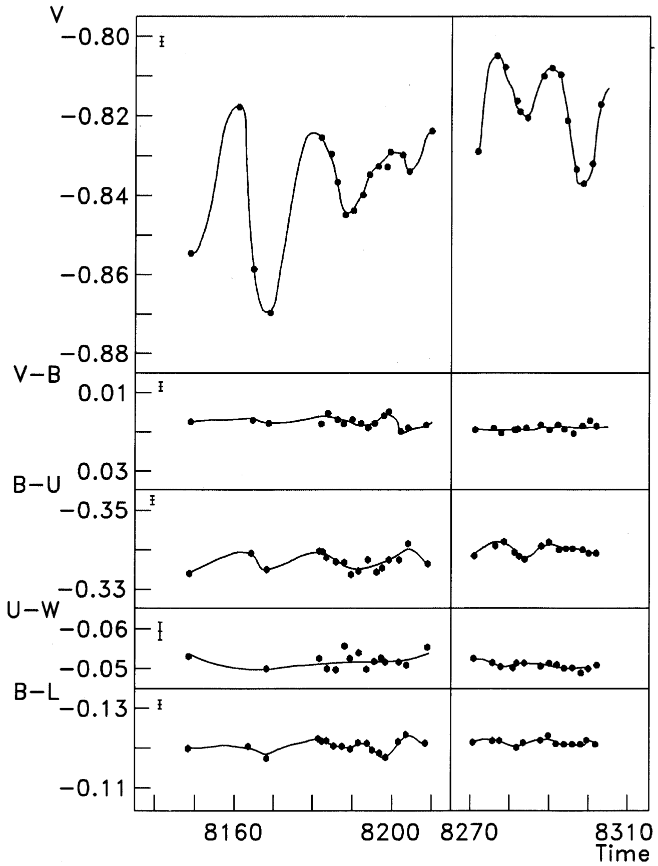

Fig. 7. A portion of the light and colour curves of R 103 relative to the comparison star in log intensity scale as a function of JD - 2440000. Bright and blue are up. Error bars are twice the mean error.

and 1963, and by van Genderen et al. (1982) made in 1979, are practically equal to those listed in Table 2 (note that the $(B-V)_J$ in the last reference should be read as -0.008 and not as -0.08).

Fig. 7 shows the light and colour curves (in log intensity scale) as a function of Julian Date during two months in 1990/91. The error bars represent twice the average mean error. The time-scale of the variations is of the order of a few weeks. The search for the period was made between 10 d and 50 d. Fig. 8 gives the amplitude and window spectrum for the V data. The highest peak in the amplitude spectrum is at 0.0419 cd^{-1}($P = 23.85$ d), with adjacent 1 cycle per year aliases. The phase diagram for this best period displays a scatter of $\sim 0\overset{\mathrm{m}}{.}05$ around the mean curve which itself has an amplitude of $0\overset{\mathrm{m}}{.}04$. Only the colour curve $B-U$ shows a significant cyclic behaviour of $0\overset{\mathrm{m}}{.}01$ amplitude, blue at maximum light and red at minimum light, which is normal for α Cyg variables. It is impossible to say anything about the physical reality of the other periods.

3.3. *R 123 = HD 37836 = -69 201 = S 124,* Bpec

R 123 appears to be variable with a maximum light amplitude of $0\overset{\mathrm{m}}{.}32$, which is abnormally high for such an early B type supergiant (see Fig. 13 in van Genderen et al. 1992).

Stahl et al.'s (1984) compilation of photometric data between 1960 and 1984 showed a total range of $0\overset{\mathrm{m}}{.}18$, hovering between $10\overset{\mathrm{m}}{.}5$ and $10\overset{\mathrm{m}}{.}7$. The magnitude V_J = 10.47 (December 1984, Stahl & Wolf 1987), the average magnitude of the present paper V_J = 10.61 and the Hipparcos magnitude (for 1989–1993) Hp = 10.55 ($\sim$ V_J—van Leeuwen et al. 1998) fits very well in this sequence. (It must be noted that the Hipparcos light curve looks like a scatter diagram and no cyclicity is evident, contrary to the data discussed below. Nearby faint field stars may have contaminated the Hipparcos photometry).

The light curve of R 123 V clearly demonstrates that R 123 exhibits at least two types of variation: a long time-scale one ($\sim$ 1 y) with a range of $\sim 0\overset{\mathrm{m}}{.}22$ and, superimposed on it, α Cyg-type variations with a time-scale of a few days and an amplitude of $\sim 0\overset{\mathrm{m}}{.}13$.

Before we describe the search for periods, it is of interest to discuss first the historical photometric behaviour of R 123. Compilations by Thackeray (1974) for observations between 1834 and 1974 and by Stahl et al. (1984) for observations between 1959 and 1984 (to which we can add the one by van Genderen 1970, made in 1966) demonstrate that the star was $\sim 0\overset{\mathrm{m}}{.}5$ brighter in the 19th century. Thus, R 123 is also subject to a third type of variablility on a time scale of at least a few decades to one century.

A period search in the domain 0.003–0.1 cd^{-1}was carried out; see Fig. 9 for the corresponding V-amplitude spectra. A strong (double) peak occurs in the amplitude spectrum at 0.0025 ($P = 400$ d) and 0.0036 cd^{-1}($P = 278$ d)(note that the highest peak in the spectral window is at 0.00288 cd^{-1}or $P = 347$ d). Some lesser peaks appear, but the most prominent time-scale of R 123's photometric variations is obviously $\sim$ 300 d. In order to choose which of these periods gives the best phase diagram we used the period search program of Sterken (1977), which is based on a sine curve fit to the data. The period with the highest correlation coefficient (r = 0.630) then appears to be 292 d $\pm$ 20 d. Our data partly cover three such cycles in a row.

Fig. 10 shows the corresponding phase diagram for V, $B-L$ and $B-U$ (the scales of the latter two diagrams are twice as large as for V). The amplitude of the sketched curve amounts to 0.09 log intensity scale or $0\overset{\mathrm{m}}{.}22$. The large scatter is mainly caused by the α Cyg-type variations. The two colour curves clearly show a cyclic variation. They are blue in the light minimum and red in the light maximum, strongly suggesting an S Dor-variation. Most peculiar is the fact that the scatter in $V-B$ (curve omitted) is twice that in $B-L$ and $B-U$, even slightly more than in $U-W$ and without a cyclic variation (see further).

To search for α Cyg-type variations with a much shorter period, all V and B datapoints were corrected for the three individual 292 d cycles. As zeropoints we used the V and B values -1.12 and -1.19, respectively, corresponding with the brightness at minimum light of the 292 d-cycle. Then, a new period search was made (with the algorithm of Sterken 1977), and yielded a most probable period $P = 3.91$ d. The phase diagram with this best period is shown in Fig. 11 for V, $V-B$, $B-L$ and $B-U$.

There is something very peculiar with the 3.91 d-colour variations: those for the observations belonging to the first and sec-

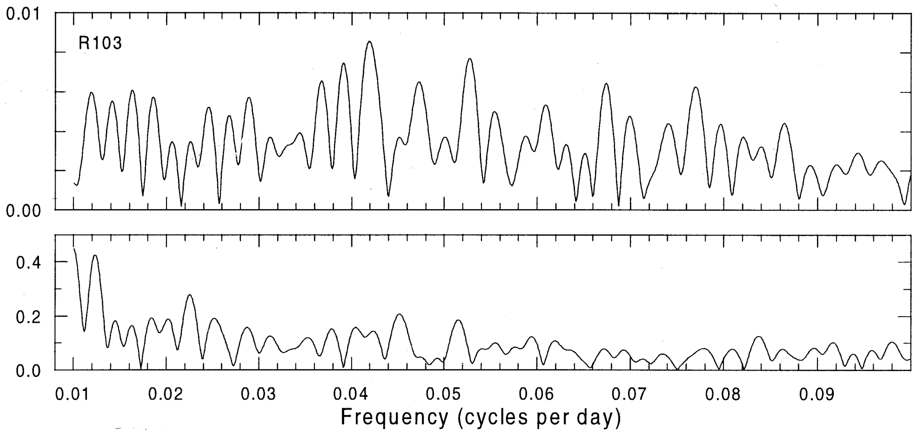

Fig. 8. Amplitude spectrum (top) and spectral window (bottom) for V measurements of R 103

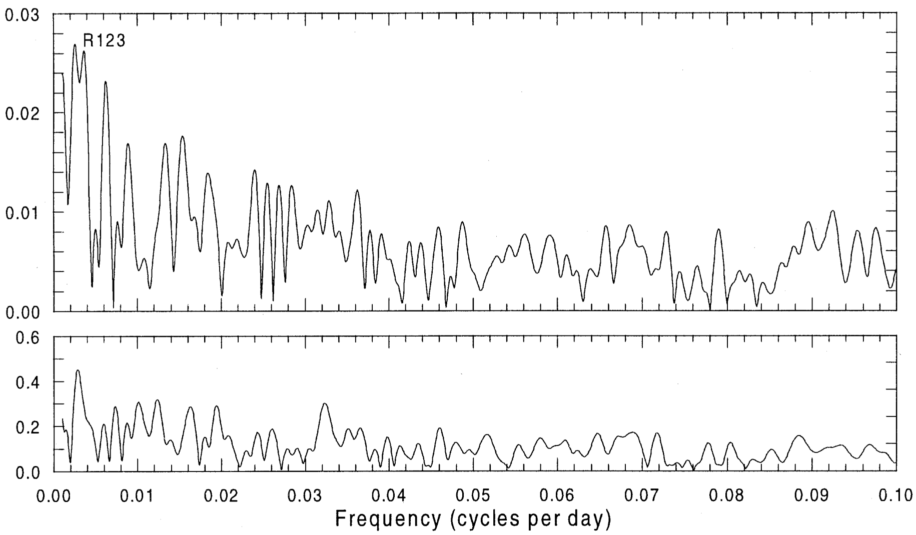

Fig. 9. Amplitude spectrum (top) and spectral window (bottom) for V measurements of R 123.

ond cycle (continuous curve) of the 292 d-variation show a different phase dependence from those belonging to the third cycle (broken curve, observations after JD 244 8113). In additon, the mean colours are redder during the third 292 d-cycle. There is no significant difference between the three 292 d-cycles in V. Now it is also clear why the omitted $V - B$ curve in the phase diagram folded with the 292 d-period (Fig. 10) showed such a large scatter: $V - B$ shows the largest intrinsic colour range.

Because of this marked dichotomy we decided to repeat the search with the observations of the first and second 292 d-cycle separated from that of the third one. The result is that for the first two 292 d-cycles the 3.910 d (r = 0.638) period is by far more significant than the 1.344 d (r = 0.485) and 1.338 d (r = 0.478) periods. However, the reverse is the case for the third 292 d-cycle: 1.342 d (r = 0.711) is now the most significant one (note the small difference in the third decimal), 3.910 d (r = 0.662) is present again and a new period of 1.362 d (r = 0.523) appears.

Thus, it seems that the star has (at least) two types of short-period oscillations: sometimes 3.910 d is the dominant time-scale, here apparently during the first two 292 d-cycles, and at other times, here during the third 292 d-cycle, the 1.342 d oscillation is more prominent.

It is noteworthy that the colour curves of the 1.342 d period also show a substantial shift with respect to the light curve: they are nearly in antiphase, like in Fig. 11. Thus, red in the maxima and blue in the minima. This is quite exceptional for an α Cyg-type variation. We cannot offer an explanation for the time dependence of the colours, amounting to 1-3%.

3.4. R 128 = HDE 269859 = -69 221, B2 Ia

R 128 varied with a total range of $0\overset{\mathrm{m}}{.}32$ (between 1983 and 1990), which is very large with respect to its spectral type (see Fig. 13 in van Genderen et al. 1992). According to the compilation of Stahl et al. (1984), R 128 varied over not less than $0\overset{\mathrm{m}}{.}55$ between 1969 and 1984, which is mainly due to a very faint magnitude obtained by Sterken (1980, pr. comm. to Stahl et al. 1984).

The time-scale of the variations is difficult to determine. The light curve looks rather chaotic with sharp peaks and dips, alternated by slow low-amplitude variations, on time-scales of a week to a month, respectively.

Fig. 12 shows an example of the light and colour curves (in log intensity scale) for the interval 1989-1990.

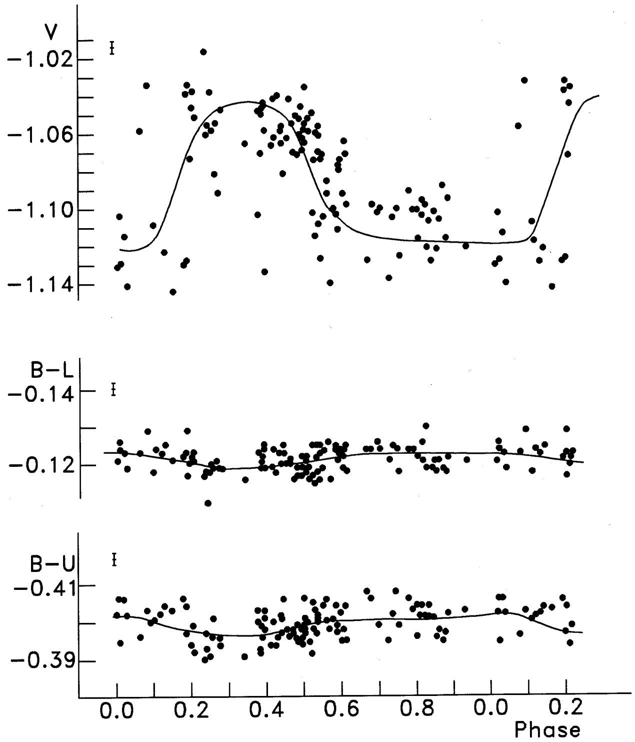

Fig. 10. The phase diagram of R 123 in log intensity scale, folded with P = 292 d. Bright and blue are up. Error bars are twice the mean errors.

The amplitude spectrum is given in Fig. 13. The best period is 3.444 d, but the phase diagram is not convincing.

Possibly, R 128 is subject to multi-periodicity and stochastic perturbations. In the colour curves $B - U$ tends to be bluer in the maxima than in the minima which is normal for α Cyg-type variations.

4. Discussion and conclusions

We have investigated the photometric characteristics of four variable LMC supergiants (α Cyg variables), three of which are strong emission-line objects and two are suspected LBV candidates. According to the photometric characteristics these two can be considered as true active LBVs near minimum light, but not spectacular.

4.1. R 99 = HDE 269445

The spectroscopic classification of this peculiar emission-line star met with difficulties due to its contradictory spectral characteristics. Classifications, based on spectra made between 1973 and 1994 and depending on the criterea used (Walborn 1977, 1982; Shore & Sanduleak 1984; Stahl et al. 1984; Bohannan & Walborn 1989; Pasquali et al. 1997a, b; Crowther & Smith 1997), run from OBf:pe to B0.5 Ia, WN9, and WN10h. In the optical region it has a pure emission-line spectrum (Walborn 1982; Bohannan & Walborn 1989). A luminous disk might be one of the reasons for the controversy (Stahl & Wolf 1987).

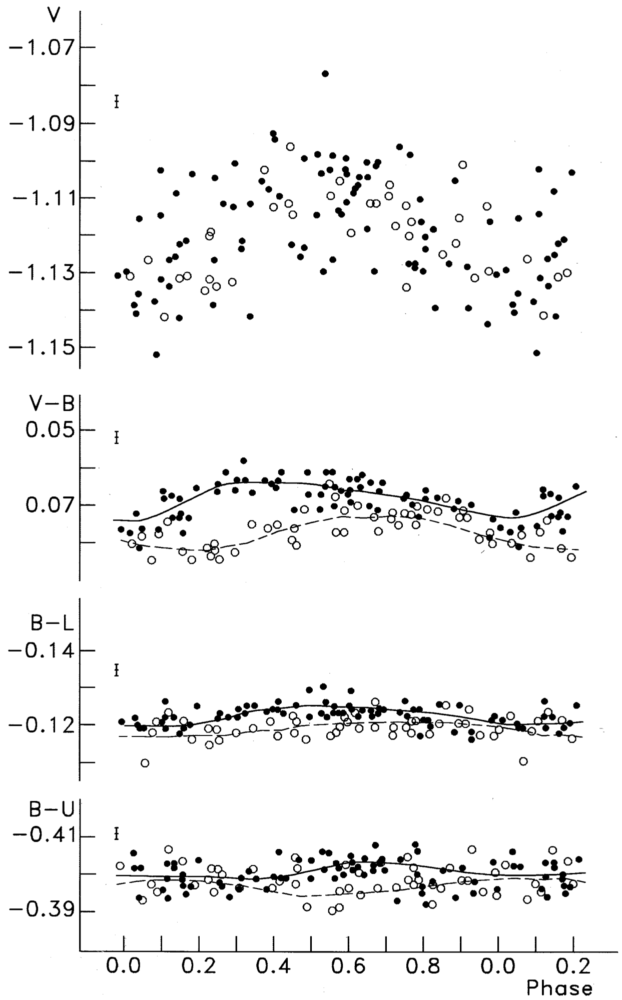

Fig. 11. The phase diagrams of the residuals of the 292 d cycles of R 123 folded with a period $P = 3.910$ d. The continuous and broken curves run through the observations of the first two and third 292 d-cycles, respectively. Bright and blue are up. Error bars are twice the mean error.

Anyway, it is at least a member of the group of Ofpe/WN9 stars (Bohannan & Walborn 1989).

Whether the varying classification is partly due to the VLT-SD cycle (Sect. 3.1) with a time-scale of ~ 3 decades is questionable, because of its small range of $0\overset{\mathrm{m}}{.}3$.

From the photometric point of view R 99 is peculiar, too. The light and colour ranges of the α Cyg-type variations are larger by a factor 4 and 5-10, respectively, (within a two-year interval, thus independent of the VLT-SD cycle) than those in other α Cyg variables (see Fig. 13 in van Genderen et al. 1992 and Fig. 6 in van Genderen et al. 1990).

Further, the α Cyg-type variations seem to be subject to at least two types of oscillations. The first one has a period of 2.088 d. With this period its colour curves are not all precisely in phase with the light curve. This is not a normal habit for α Cyg variables. When the light ranges in the W passband are significantly smaller than those in the U passband, they appear to be modulated by the longer period of 9.98 d. Normally, light

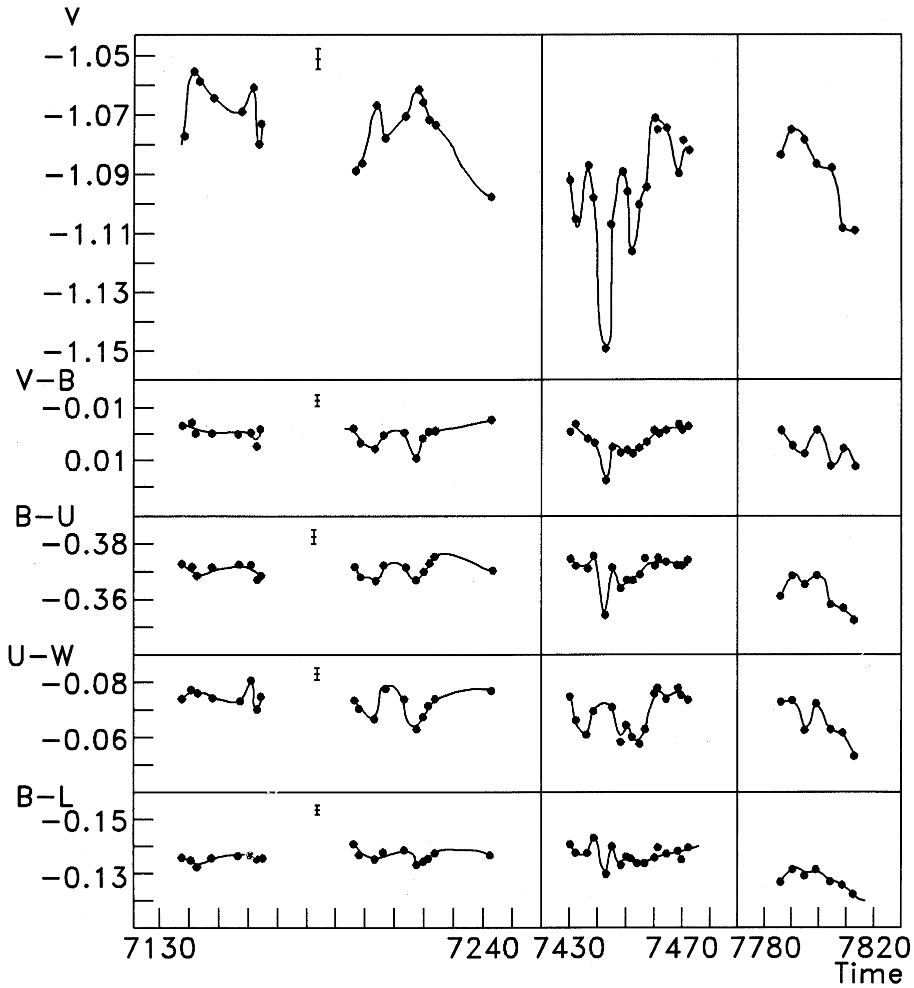

Fig. 12. A portion of the light and colour curves of R 128 relative to the comparison star and in log intensity scale as a function of JD - 2440000. Bright and blue are up. Error bars are twice the mean error.

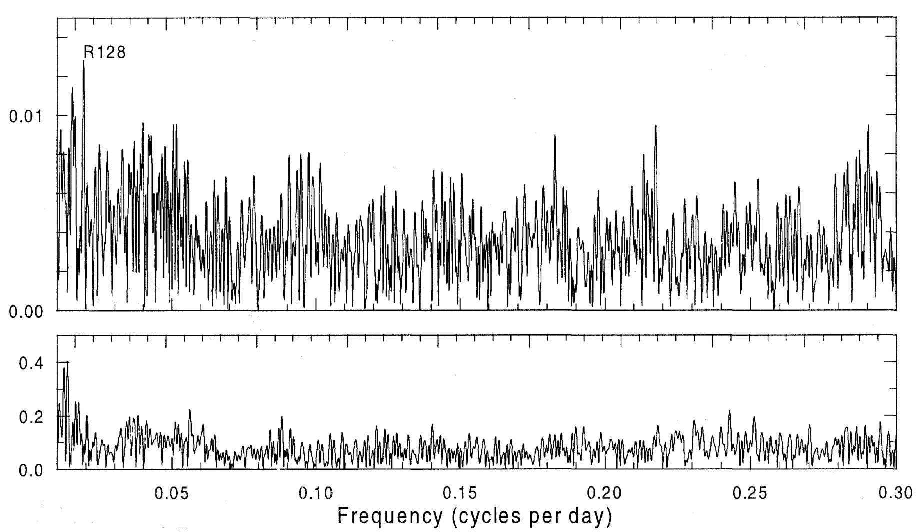

Fig. 13. Amplitude spectrum (top) and spectral window (bottom) for V measurements of R 128.

ranges in these stars increase to shorter wavelengths, but here the U passband is at the longer wavelength. These peculiarities could be due partly to emission-line variations originating in an extended envelope and/or luminous disk.

R 99 can be considered as an active LBV, but only subject to the longer type of SD phase: the VLT-SD cycle, with a small range of $0\overset{m}{.}3$. AG Car, S Dor and other LBVs show this type of SD phases with ranges up to 1^m lasting a few decades. Besides, they are also subject to a second type of SD phase: the "normal SD phase", superimposed on the first one (van Genderen et al. 1997a, b). As concluded by different researchers, SD phases are mainly caused by a slow radius and temperature variation

(Leitherer et al. 1989; de Koter et al. 1996; van Genderen et al. 1997a).

Other Ofpe/WN9 stars are still considered as dormant LBVs by Pasquali et al. (1997a, b; because no associated circumstellar nebula has been detected and resolved), Pasquali (1997) and Crowther & Smith (1997). In the latter paper the spectral characteristics of R 99 are compared with those of the WN10h star and supposedly dormant LBV HV 5495 (= HDE 269582 = BE 294) (Bohannan 1989). According to the photometric study of van Genderen & Sterken (1996), it is also an active LBV (although no associated circumstellar nebula has been detected), but near minimum brightness between 1989 and 1993, only showing normal SD phases, with amplitudes of $0^{m}.3$ to $0^{m}.5$ and a time scale of 1 to 2 y. Between 1890 and 1910 it showed a VLT-SD phase with a range of $1^{m}.2$ and a cycle length of 20 y according to the photographic observations by Hoffleit (1940).

4.2. R 103 = HDE 269546

This supergiant was classified as B3 Ia by Feast et al. (1960) and as B5 Ia by Ardeberg et al. (1972). Considering its total light range, it has a hypergiant character but the precise quasi-period is uncertain; the time-scale of the light variations is 3 to 4 weeks.

4.3. R 123 = HD 37836

It is difficult to define a spectral type for R 123. It has clear P Cyg characteristics: Bpec (Feast et al. 1960), or a late O-type (Stahl & Wolf 1987). Like R 99 (Sect. 4.1), the optical spectrum is dominated by emission lines, presumably from a disk (Stahl & Wolf 1987).

Photometrically, R 123 is complicated as well and subject to at least four types of light variation (Sect 3.3). The first one has a time scale of a few decades to a century, since R 123 was $\sim 0^{m}.5$ brighter in the second half of the 19th century. The second one has a cycle length of 292 d and a range of $0^{m}.22$ with colours red in the maxima and blue in the minima. This points to an S Dor-variation. Thus, both types of variation likely represent the VLT-SD and normal SD phases, respectively. Incidentally, such a small range for the normal SD phases is not exceptional, since AG Car also showed them near minimum brightness. It is of interest also to note that in AG Car the (stable) period is 371 d (van Genderen et al. 1997a; Sterken et al. 1996), not much longer than the 292 d of R 123.

The two other types of variation are caused by α Cyg-type variations with amplitudes of $0^{m}.13$, and periods of 3.910 d and 1.342 d, dominant during the first two and last cycles of the 292 d variation, respectively. These periods are much shorter than for AG Car's α Cyg-type variations near minimum light: $\sim$ 2 weeks (van Genderen et al. 1990). Incidentally, AG Car's spectral type then was WN11 (Smith et al. 1994).

We conclude that R 123 is an active LBV, but much less spectacular than AG Car, S Dor, etc.

4.4. R 128 = HDE 269859

According to Walborn et al. (1991) R 128 has emission lines and shows an N-deficiency. It has been classified as B2 Ia. Our detailed photometry shows very complicated fluctuations on a varying time-scale of a week to a month with a total range of $\sim 0^{m}.3$. No reliable period or quasi-period could be found. Colours are generally blue at maximum light and red at minimum light, which is normal for α Cyg variables.

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