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Research Note

Short-timescale light variations of the Wolf-Rayet stars WR 46 and WR 86*

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Summary. Monitoring of four Wolf-Rayet stars (WR 22, WR 46, WR 86, and WR 93) in the *VBLUW* system of Walraven, each during a whole night are presented and discussed. Two of them appeared to be constant during the time of observing, viz. WR 22 (WN 7+a) and WR 93 (WC 7+O 7–9), in contrast with the other two stars WR 46 (WN 3 pec) and WR 86 (WC 7 + a). Their light amplitudes are $0\overset{m}{.}075$ and $0\overset{m}{.}025$, respectively, and the time scale for both amounts to ~ 3 h. The second object became slightly bluer during maximum light.

Key words: photometry – variable stars – Wolf Rayet stars

1. Introduction

The search for radial and non-radial pulsations of Wolf-Rayet (WR) stars has been undertaken since a number of years. According to Maeder (1985) He burning WR stars with mass loss should show *radial* pulsations with typical periods in the range of 15–60 min. Noels and Scuflaire (1986) have shown that short time scale (of hours) *non-radial* modes can develop if WR stars have an H burning shell also. A compilation of observed variations in WR stars in various spectral ranges is given by Vreux (1987). He expresses the hope that some of the variations could be linked to pulsations, but this is not yet established.

The reasons are likely:

1. that the extended envelope masks the photosphere of most of the WR stars.
2. that many of the most intensively investigated WR stars are double stars, giving rise to binary modulation in the brightness, masking any smaller amplitude oscillations. It is true that most of these light curves show a large intrinsic scatter, but their real nature is not yet well investigated. Instabilities in the wind and envelope may as well be an important cause of photometric and spectroscopic short time scale variations (van Genderen et al., 1987 and references therein).
3. that so far only a small number of single WR stars were subject of high precision photometric monitoring, for which the Walraven photometer is an ideal instrument (e.g. Magain et al., 1987, on the WN 7 star WR 78).

Photometric attempts have been made by Lamontagne and Moffat (1986) on the WO type star WR 142 during 4 h and by van Genderen et al. (1987) on the three WN 7 + a objects WR 22, WR 24 and WR 25 during one hour, but without finding significant variations. The WR numbers refer to the catalog of van der Hucht et al. (1981).

In this note we discuss the results of the monitoring of four WR stars (WR 22, WR 46, WR 86, and WR 93), each during a sequence of ~ 5 h in one night, in April 1986.

2. The observations and reductions

The observations were made with the 90 cm Dutch telescope at the European Southern Observatory (ESO), La Silla, Chile, equipped with the *VBLUW* photometric system of Walraven, during four nights in April 1986 by one of us (P.M.). A detailed description of the photometric system is given by Lub and Pel (1977) and references therein. The diaphragm aperture was 16″. Integration times were usually of the order of 4 min per measurement.

Each of the four program star was measured alternately during ~ 5 h with two nearby comparison stars. All stars were calibrated by means of standard stars measured throughout each night. Plots of the differences $v - c_1$, $v - c_2$ and $c_1 - c_2$ against Universal Time (UT) were made. If both stars c_1 and c_2 turned out to be stable, the measurements of c_2 were transformed into c_1 with the aid of the average value $c_1 - c_2$. Afterwards the differences $v - c_2$ were transformed into $v - c_1$. Table 1 lists the four dates in which each of the four program stars and their comparison stars were measured. The column V_J lists the V of the *UBV* system in magnitude scale transformed from the V of the *VBLUW* system, with the aid of the formula from Pel (1985): $V_J = 6.885 - 2.5$

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* Observations collected at the ESO, La Silla, Chile

Table 1. Dates, program and comparison stars

Date	Star	Sp	v [1]	V_J [6]
13 April 1986	WR 93 = HD 157504	WC7 [1] + O7–9 [2]	11.46	10.23
	C_1 = HD 156662	B2 III [4]		7.85
	C_2 = HD 157063	Ap Si [4]		8.51
14 April 1986	WR 46 = HD 104994	WN3 pec [1]	10.96	10.95
	C_1 = HD 104901	B8/9Iab/b [3]		10.18
	C_2 = HD 104918	B5/7V [3]		10.03
15 April 1986	WR 86 = HD 156327	WC7+a [1]	9.73	9.29
	C_1 = HD 156424	B2Ib/II [5]		8.76
	C_2 = HD 163924	B2III [5]		8.99
16 April 1986	WR 22 = HD 92740	WN7+a [1]	6.44	6.39
	C_1 = HD 92938	B3/5V [3]		4.79
	C_2 = HD 93163	B3IV/V [3]		5.75

References and notes:
1. van der Hucht et al. (1981)
2. Lortet et al. (1984)
3. Houk and Cowley (1975)
4. Houk (1978)
5. Houk (1982)
6. The V_J of the UBV_J system in magnitude scale transformed from the V_w of the *VBLUW* system, see Sect. 2

Table 2. Individual observations in the V band of the *VBLUW* systems (in log int. scale) of WR 46 and WR 86 relative to their comparison stars

WR 46 – HD 104901		WR 86 – HD 156424	
Date 14 April 1986		Date 15 April 1986	
UT	ΔV	UT	ΔV
1^h48^m	−0.3178	3^h20^m	−0.2258
2 10	−0.3194	3 41	−0.2260
2 35	−0.3154	4 3	−0.2282
2 49	−0.3115	4 24	−0.2278
3 15	−0.3062	4 43	−0.2252
3 28	−0.3018	5 5	−0.2201
3 45	−0.2924	5 26	−0.2176
3 59	−0.2917	5 45	−0.2190
4 16	−0.2966	6 6	−0.2218
4 29	−0.3029	6 25	−0.2247
4 46	−0.3104	6 49	−0.2268
5 9	−0.3178	7 9	−0.2303
5 31	−0.3170	7 32	−0.2295
5 53	−0.3143	7 52	−0.2259
6 16	−0.3040	8 11	−0.2205
6 40	−0.2924		
7 8	−0.2951		

$[V+0.030\ (V-B)]$. The result is based on an average of the calibrated measurements. The estimated accuracy in these V_J values is $\leqq 0^m.05$.

Two program stars, WR 22 (WN 7 + a, SB 1, P = 80.35 days) and WR 93 (WC7+O 7−9) turned out to be constant during the night of observing. However, WR 22 appeared to be slightly variable with a range of $\sim 0^m.02$ during a time interval of 11 nights, just two weeks before the date of monitoring, and with a time scale of ~ 1 d (van Genderen et al., 1987). The discovery and classification of the O-type companion of WR 93 is by Lortet et al. (1984). No period is known as yet. Williams et al. (1987a) list this star as a possibly long-term IR variable similar to WR 140 (Williams et al., 1987b).

The comparison star c_1 (of spectral type B 2 III) of WR 93 was presumably variable during the night. Its variability should be further investigated.

The other two program stars WR 46 (WN 3 pec) and WR 86 (WC 7 + a) turned out to be variable in the nights of observing. Unfortunately, WR 86 has an optical companion at 0″.2 (Jeffers et al., 1963). However, its spectral type is B0 V (Smith, 1986), implying it is $1^m.5$ fainter than the WC 7 star (van der Hucht et al., 1987). We expect it to be non-variable. Table 2 lists the individual values of the V band of the *VBLUW* system, called ΔV (in log intensity scale) relative to c_1. WR 46 has been listed as a possibly variable object by Underhill (1968). In the literature WR 46 and WR 86 have never been mentioned in the context of spectroscopic binaries.

3. Discussion

Figures 1 and 2 show the plots for WR 46 − c_1 and for $c_1 - c_2$, respectively. Figs. 3 and 4 those for WR 86 − c_1 and for both comparison stars of WR 86, $c_1 - c_2$. Error bars represent the standard deviations σ based on the results of the comparison stars. They vary between $\pm 0^m.002$ and $\pm 0^m.005$. The results are most revealing. Both stars WR 46 and WR 86 show light variations with amplitudes of $0^m.075$ and $0^m.025$, respectively, but with an equal time scale of ~ 3 h. The rising branch of the second cycle suggest similar characteristics as for the first one. At the present stage it cannot be said whether the variations are cyclic.

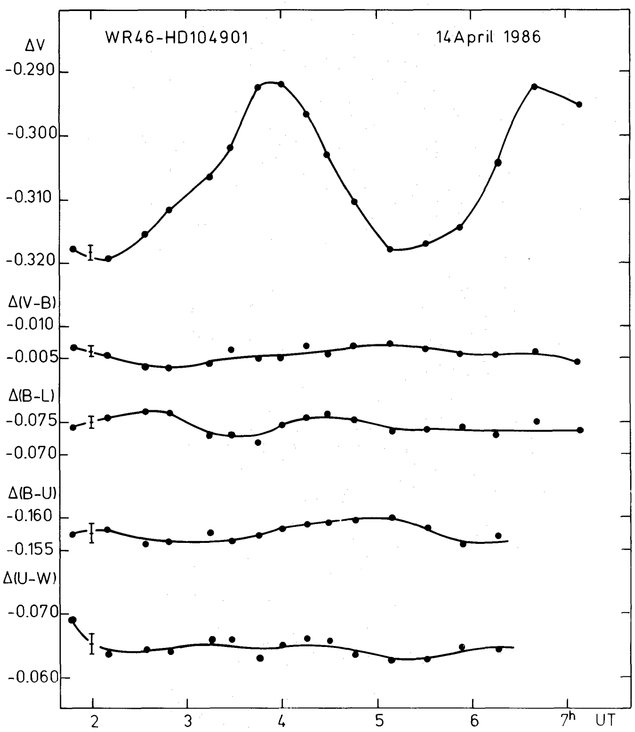

Fig. 1. The light and colour curves (in log int. scale) of WR 46 of spectral type WN 3 pec, relative to the comparison star c_1, as a function of Universal Time

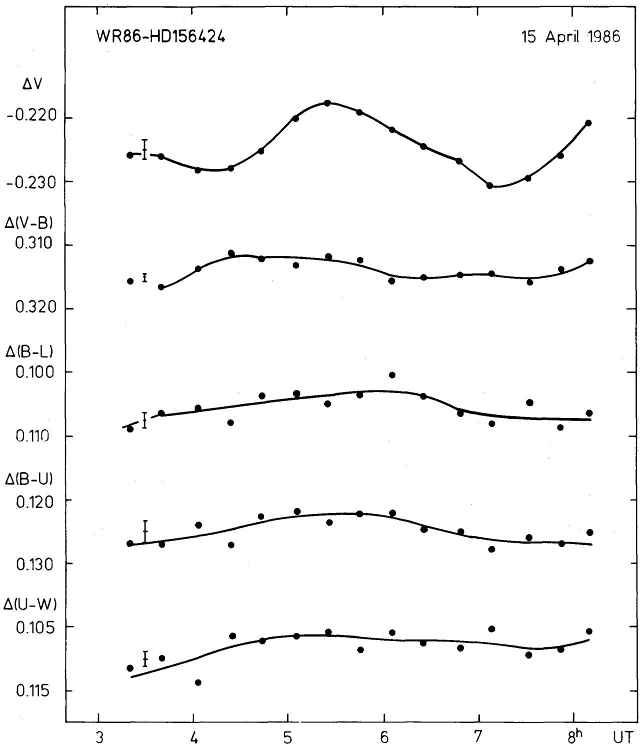

Fig. 3. The light and colour curves (in log int. scale) of WR 86 of spectral type WC 7 + a, relative to the comparison star c_1, as a function of Universal Time

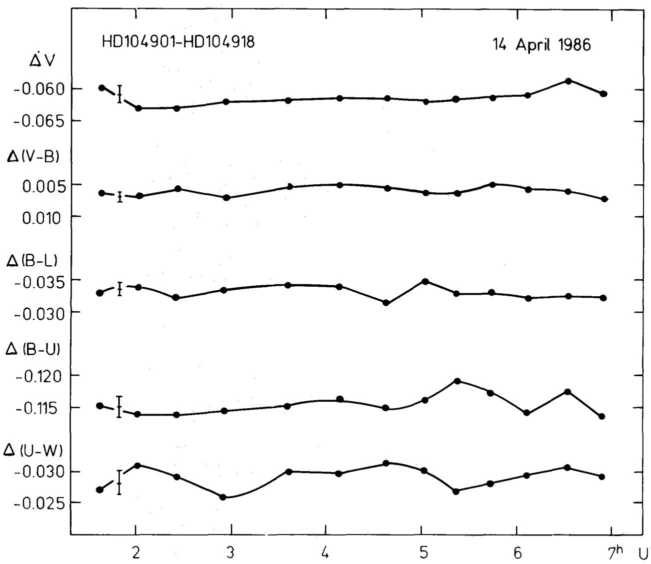

Fig. 2. The light and colour curves (in log int. scale) of the two comparison stars of WR 46 relative to each other, as a function of Universal Time

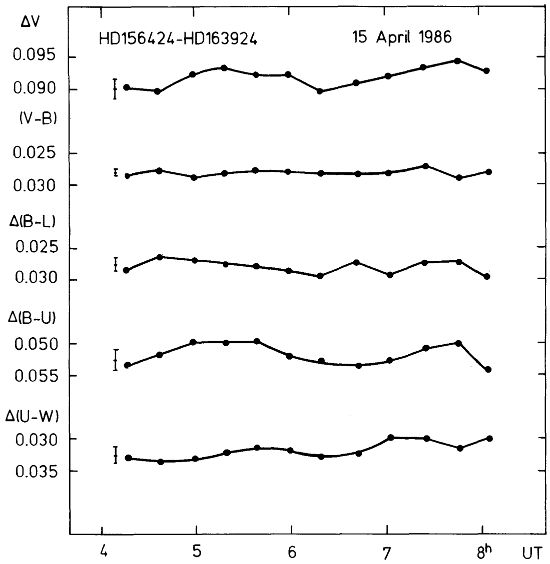

Fig. 4. The light and colour curves (in log int. scale) of the two comparison stars of WR 86 relative to each other, as a function of Universal Time

No colour variations larger than the standard deviation are detected for WR 46, opposite to those of WR 86, where a blueing during maximum light is obvious. (In $V-B$ the blueing starts at minimum light, but in view of the size of σ more observations are necessary to confirm this.) This phenomenon could point to a temperature effect, for example caused by the appearance of hot blobs, holes or eddies in the envelope. At least such a suggestion has been offered by van Genderen et al. (1987) to explain the colour variations in a number of other WR stars also observed in the *VBLUW* system.

The crucial point whether we are dealing with an envelope disturbance or with an oscillatory phenomenon, can perhaps only be answered if we know whether the variations appear to be strictly periodic, semi-periodic or completely irregular. Long term monitoring of these two objects are planned with the same photometer, partly in conjunction with spectroscopy and polarimetry.

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