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On the distance to the new luminous blue variable WRA 751 and its variability *

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Abstract. VBLUW photometry of field stars around the new LBV, WRA 751, is presented and dicussed in order to determine its distance with the aid of the reddening-distance method. With a reddening for WRA 751 of $E(B-V)_J = 1\overset{m}{.}45$ - $1\overset{m}{.}80$; in which the circumstellar reddening of $\leq 0\overset{m}{.}40$ is taken into consideration, the distance should be $r \geq 4$ - 5 kpc, respectively, confirming Hu et al.´s (1990) suggestion. VBLUW photometry of WRA 751 is also presented and discussed in order to analyze its variability. This shows a light amplitude of $0\overset{m}{.}15$ with a time scale of $\sim 30^d$ and superimposed short time scale variations ($\sim$ a week) with amplitudes of $\sim 0\overset{m}{.}03$.

Key words: photometry – stars: supergiant – stars: variable – stars: HR diagram – stars: individual: WRA 751.

1. Introduction

The variable star WRA 751 = Hen 3-591 = IRAS 11065-6026 has been studied by Hu et al. (1990) and in more detail by de Winter et al. (1992). They determined various physical parameters and concluded that the star is a new member of the small class of hot S Dor type stars or luminous blue variables (LBVs). The temperature is likely to be of the order of 30 000 K (equivalent to a spectral type O9.5), the lower limit of the luminosity log $L_*/L_\odot = 5.7$ and the mass loss rate is $-5.5 < \log \dot{M}_\odot < -6.0$. In order to know the position of WRA 751 with respect to the Humphreys-Davidson (HD) limit better, a more precise distance determination is desirable. Its location is towards the direction of the Carina spiral arm beyond the Carina nebulosity. We have estimated its distance by means of the reddening-distance method, based on multi-colour photometry of field stars located close to WRA 751. Applications of this method appeared to be succesful for AG Car and HR Car (Hoekzema et al. 1992 and van Genderen et al. 1991, respectively).

We have also tried to find the quasi-period ($\bar{P}$) of the intrinsic oscillations of WRA 751 by monitoring the object photometrically in 1990 and 1991. Previous investigations show that the $\bar{P}$s of the LBVs R 71, AG Car, HR Car and P Cyg fit the PLT$_{eff}$ relation for variable supergiants reasonably well (van Genderen et al. 1988, hereafter Paper VI; van Genderen et al. 1990, hereafter Paper XI; van Genderen et al. 1991, and van Genderen 1991a; see also Fig. 5 of this paper). Thus if for WRA 751 T$_{eff}$ and $\bar{P}$ are known, M$_{bol}$ can be estimated roughly.

2. The observations

The observations were made with the 90 cm Dutch telescope at the ESO, La Silla, Chile, equipped with the Walraven VBLUW photometer. Slightly more than 100 field stars within an area of 10′ around WRA 751 were selected and measured in one to four nights in February and May 1990 by two of us (J.P.d.J. and A.H., respectively) through a 16″ aperture. The brightest star HD 96946 (= no. 3 in Fig. 1) is of magnitude 8.5 and has an HD spectrum of B5. The limiting magnitude is about 14.5. Integration times for stars as well as for the sky background varied between 2 to 6 minutes in accordance with their brightnesses. The extinction coefficients and the calibration constants were determined using measurements of a large number of standard stars made each night. Dependent on the brightness of the star, most of the standard deviations (σ) varied between 0.005 and 0.050 in V, 0.005 and 0.030 in $V-B$ and $B-L$, and 0.010 and 0.050 in $B-U$ (all in log intensity scale). Due to the low signal in the W channel ($\lambda_{eff} = 3235\AA$), the colour index $U-W$ could only be applied for blue stars brighter than $\sim$ 13th mag. For these ones most of the standard deviations were of the same order as that for $B-U$. Fig. 1 shows the identification chart of the field stars around WRA 751 (= star no. 1). Table 1 lists the photometric data in the VBLUW system (in log intensity scale) and in the UBV parameters V_J and $(B-V)_J$ transformed from the equivalent V and $V-B$ Walraven values using the formulae of Pel (1987):

$$V_J = 6.886 - 2.5[V + 0.033(V-B)] \quad (1)$$

$$(B-V)_J = 2.571(V-B) - 1.020(V-B)^2 + 0.500(V-B)^3 - 0.010 \quad (2)$$

The first formula can be applied to stars bluer than $(B-V)_J \sim 1\overset{m}{.}5$ and not too much reddened, with an accuracy $\leq 0\overset{m}{.}01$.

Three stars (nos. 30, 31 and 51) marked on the chart are omitted in Table 1 due to poor photometric results. Stars nos.

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*Based on observations made at the European Southern Observatory, La Silla, Chile

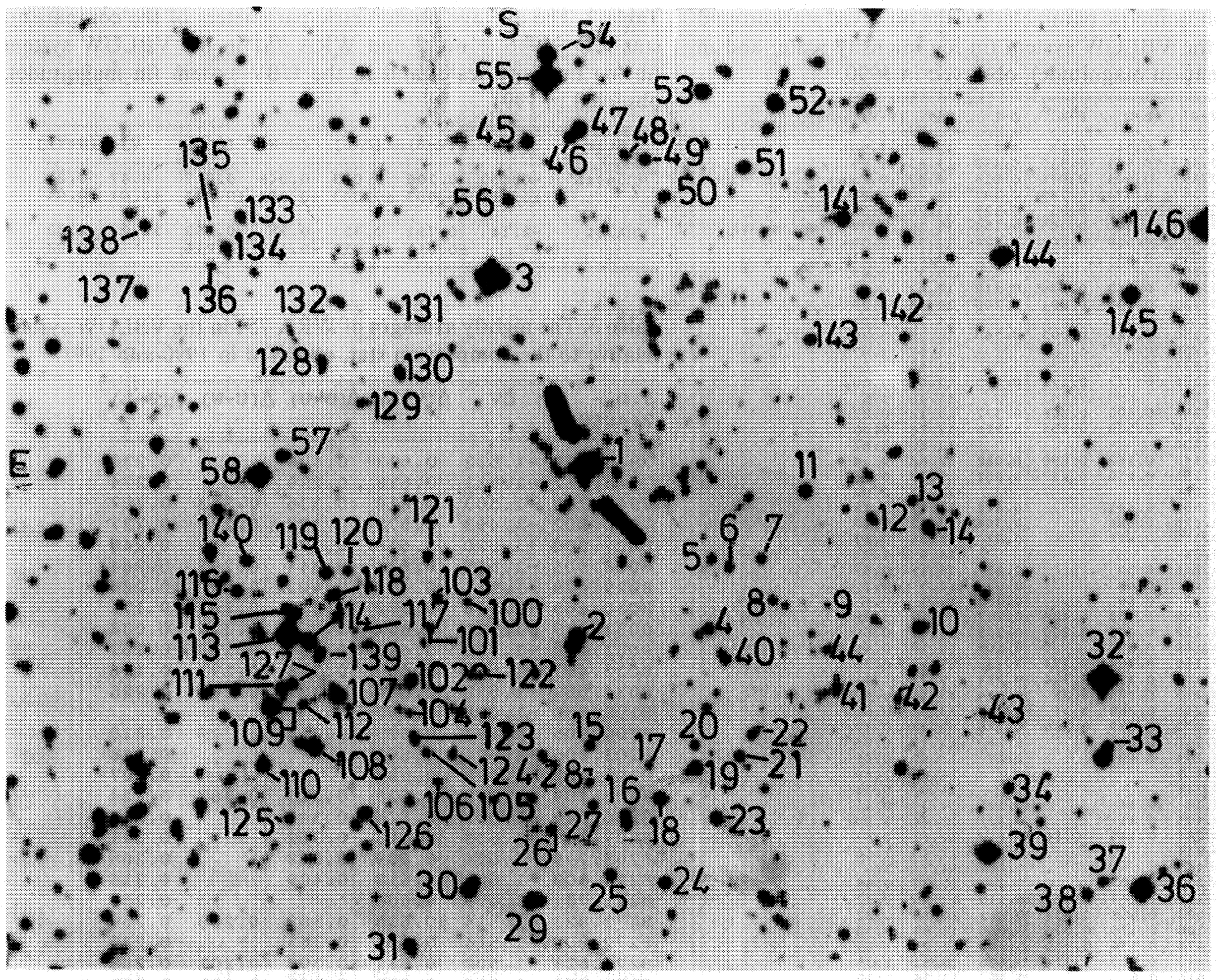

Fig. 1. The finding chart of WRA 751's neighbourhood. The observed stars are marked by a number (WRA 751 = no.1) and lie within a radius of 10′ around WRA 751

32, 132 and 146 are optical binaries. Both components were measured, but the photometric results are unreliable, due to their mutual influences.

WRA 751 (no. 1) was measured thirteen times in February and May, 1990, showing that the star is variable indeed on a time scale of days to weeks. Table 1, listing the photometric parameters of the observed stars around WRA 751, also lists the average photometric parameters of WRA 751 (no. 1) based on these thirteen observations. They are very close to those listed by Hu et al. (1990) measured in March 1989 and differ slightly from those of Table 2, which lists the average photometric parameters obtained during January and February, 1991. These differences are 0.01 in V and $V-B$, 0.05 in $B-L$, 0.04 in $B-U$ and 0.09 in $U-W$, all colours being redder in 1991. In these months WRA 751 was measured frequently by two of us (O.M.K. and M.A.W.V.) with respect to the comparison star HD 96946 (= no. 3) and with very favourable instrumental and atmospheric conditions (a clean primary mirror, a 20% light gain due to a correction of the position of the baffle of the secondary mirror by J.W. Pel and low air mass values). In November 1990 WRA 751 was also monitored during two weeks by one of us (F.v.d B.).

Table 3 lists all the nightly averages of WRA 751 for 1990 and 1991 relative to the comparison star. Each average is based on four individual observations alternately measured with the comparison star and the sky background. The integration time per measurement was 64 sec for the comparison star and sky background and 128 sec for the variable. The average standard deviation (σ) for the variable minus comparison star amounts to: ± 0.003 for V, ± 0.010 for $V-B$, ± 0.015 for $B-L$, ± 0.020 for $B-U$ and ± 0.100 for $U-W$. The mean errors are thus smaller. For the 1990 observations the standard deviations are somewhat larger and for the 1991 ones somewhat smaller than the averages given above.

3. The reddenings and the distances

The method used here to determine the reddening and the distance is more or less similar to that for the field stars of AG Car (Hoekzema et al. 1992). We shall describe it here in short. The three two-colour diagrams enabled an unambiguous determination of the average reddening and spectral type for most of the stars (Table 4). However, due to the relatively large errors in the colours of the faint stars, their reddening and spectral type determinations were not always simple; it was sometimes difficult to decide to which part of the main sequence they actually belong. For these cases, the reddening-independend two-colour diagram

Table 1. The photometric parameters of the observed stars around WRA 751 in the VBLUW system (in log intensity scale) and in the UBV system (in magnitude), observed in 1990.

No	V	V-B	B-U	U-W	B-L	VJ	(B-V)J
1	-2.15	0.72	0.34	0.26	0.23	12.2	1.50
2	-1.915	0.486	0.561	0.310	0.490	11.63	1.06
3	-0.637	0.107	0.004	0.046	0.014	8.47	0.25
4	-2.746	0.367	0.374	0.249	0.383	13.72	0.82
5	-2.731	0.138	0.288	0.13	0.129	13.70	0.32
6	-2.528	0.143	0.340	0.105	0.154	13.19	0.34
7	-2.423	0.237	0.338	0.20	0.224	12.92	0.55
8	-2.780	0.314	0.44		0.271	13.81	0.71
9	-3.38	0.39				15.3	0.87
10	-2.056	0.113	0.247	0.079	0.112	12.02	0.27
11	-1.830	0.121	0.233	0.091	0.105	11.45	0.29
12	-3.170	0.724				14.75	1.52
13	-2.553	0.150	0.326	0.093	0.160	13.26	0.35
14	-2.720	0.756				13.62	1.57
15	-2.663	0.821	0.47			13.48	1.69
16	-2.479	0.356	0.377	0.171	0.353	13.05	0.80
17	-3.055	0.78				14.46	1.6
18	-2.104	0.366	0.403	0.208	0.377	12.12	0.82
19	-1.954	0.149	0.520	0.174	0.226	11.76	0.35
20	-2.813	0.780				13.85	1.61
21	-2.379	0.143	0.162	0.090	0.088	12.82	0.34
22	-2.524	0.151	0.410	0.217	0.252	13.18	0.35
23	-2.285	0.984				12.52	2.02
24	-2.357	0.550	0.441		0.471	12.73	1.18
25	-2.510	0.498	0.588		0.364	13.12	1.07
26	-2.682	0.370	0.61		0.37	13.56	0.83
27	-2.86	0.84				14.0	1.7
28	-2.617	0.246	0.30		0.27	13.41	0.57
29	-2.18	0.49	0.41		0.33	12.3	1.1
	-2.97	0.27	0.46		0.35	14.3	0.6
32	-0.985	0.659	0.838	0.489	0.747	9.29	1.38
33	-1.602	0.252	0.360	0.225	0.239	10.87	0.58
34	-2.926	0.169	0.27		0.105	14.18	0.40
35	-2.119	0.149	0.358	0.174	0.130	12.17	0.35
36	-1.158	0.173	0.378	0.174	0.214	9.77	0.41
37	-2.530	0.273	0.370	0.28	0.234	13.19	0.62
38	-2.453	0.263	0.298	0.31	0.207	13.00	0.61
39	-1.203	0.073	0.479	0.165	0.176	9.89	0.17
40	-2.642	0.245	0.62		0.24	13.47	0.56
41	-2.729	0.284	0.49		0.27	13.69	0.65
42	-2.880	0.669				14.03	1.40
43	-2.84	0.146				14.0	0.34
44	-2.96	0.18	0.34		0.19	14.3	0.4
45	-2.234	0.405	0.45		0.42	12.44	0.90
46	-2.308	0.295	0.325	0.16	0.242	12.63	0.67
47	-2.244	0.814				12.43	1.68
48	-3.13	0.46			0.28	14.7	1.0
49	-2.368	0.212	0.50		0.24	12.79	0.49
50	-2.410	0.138	0.263	0.08	0.115	12.90	0.32
52	-1.599	0.093	0.088	0.054	0.051	10.88	0.22
53	-1.870	0.128	0.125	0.076	0.066	11.55	0.30
54	-1.753	0.475	0.536	0.300	0.468	11.23	1.03
55	-1.071	0.640	0.700	0.374	0.606	9.51	1.35
56	-2.601	0.616	0.6		0.56	13.34	1.30
57	-2.408	0.357	0.439	0.199	0.373	12.88	0.80
58	-1.174	0.135	0.174	0.106	0.075	9.81	0.32
100	-2.723	0.166	0.227	0.12	0.128	13.68	0.39
101	-2.734	0.218	0.250		0.119	13.70	0.51
102	-2.305	0.203	0.311	0.174	0.128	12.63	0.47
103	-3.471	0.62				15.51	1.3
104	-2.920	0.163	0.369	0.222	0.149	14.17	0.38
105	-2.939	0.314	0.55		0.31	14.21	0.71
106	-2.793	0.202	0.49		0.270	13.85	0.47
107	-2.140	0.213	0.375	0.23	0.222	12.22	0.50
108	-1.763	0.225	0.333	0.208	0.220	11.27	0.52
109	-1.616	0.143	0.114	0.080	0.070	10.91	0.34
110	-2.341	0.53			0.53	12.69	1.1
111	-2.388	0.149	0.207	0.114	0.105	12.84	0.35
112	-2.789	0.269	0.380		0.274	13.84	0.62
113	-1.049	0.134	0.081	0.068	0.052	9.50	0.31
114	-1.835	0.143	0.100	0.074	0.062	11.46	0.34
115	-2.362	0.181	0.263	0.136	0.133	12.78	0.42
116	-2.532	0.180	0.324	0.148	0.158	13.20	0.42
117	-2.910	0.378	0.64		0.28	14.13	0.84
118	-2.548	0.332	0.380	0.26	0.302	13.23	0.75
119	-2.166	0.152	0.172	0.078	0.092	12.29	0.36
120	-2.993	0.770			0.53	14.30	1.59
121	-2.692	0.308	0.36	0.20	0.255	13.59	0.70
122	-2.788	0.296	0.432		0.149	13.83	0.68
123	-2.948	0.464				14.22	1.01
124	-3.06	0.268	0.62		0.24	14.51	0.62
125	-2.640	0.251	0.552	0.16	0.260	13.47	0.58
126	-2.271	0.548	0.607	0.40	0.52	12.52	1.17
127	-2.712	0.181	0.332	0.13	0.140	13.65	0.42
128	-2.758	0.305	0.382		0.29	13.76	0.69
129	-2.937	0.281	0.550		0.280	14.21	0.64
130	-2.588	0.331	0.381		0.305	13.33	0.75
131	-3.16	0.44				14.7	1.0
132	-2.94	0.580	0.62			14.2	1.23
133	-2.631	0.218	0.389		0.227	13.45	0.51
134	-3.033	0.273	0.54		0.23	14.45	0.62
135	-3.068	0.349	0.37		0.37	14.53	0.78
136	-2.769	0.258	0.476		0.269	13.79	0.59
137	-2.220	0.314	0.252	0.189	0.159	12.41	0.71
138	-2.366	0.168	0.489	0.168	0.252	12.79	0.39
139	-2.811	0.287	0.34		0.17	13.89	0.66
140	-2.989	0.295	0.46		0.22	14.33	0.67
141	-2.078	0.317	0.392	0.242	0.297	12.05	0.72
142	-2.675	1.01				13.49	2.6
143	-2.326	0.151	0.316	0.16	0.147	12.69	0.36
144	-1.876	0.690	0.74		0.66	11.52	1.44
145	-1.527	0.033	0.295	0.08	0.112	10.71	0.07
146	-1.031	0.720	0.438		0.332	9.40	1.50

Table 2. The average photometric parameters of the comparison star HD 96946 = no. 3 and WRA 751 in the VBLUW system (in log intensity scale) and in the UBV system (in magnitude), observed in 1991.

Star	V	(V-B)	(B-U)	(U-W)	(B-L)	VJ	(B-V)J
HD96946	-0.639 ±0.003	0.106 ±0.003	0.003 ±0.003	0.048 ±0.003	0.017 ±0.002	8.47 ±0.01	0.25 ±0.01
WRA751	-2.14	0.731 ±0.013	0.383 ±0.019	0.35 ±0.10	0.282 ±0.016	12.2	1.52 ±0.03

Table 3. The nightly averages of WRA 751 in the VBLUW system relative to the comparison star, observed in 1990 and 1991.

J.D.- 2440000	ΔV	Δ(V-B)	Δ(B-U)	Δ(U-W)	Δ(B-L)
7945.722	-1.532	0.623	0.426		0.239
7945.812	-1.533	0.618	0.299		0.274
7948.740	-1.503	0.616	0.336	0.253	0.257
7950.802	-1.493	0.578	0.177	0.270	0.237
8027.500	-1.520	0.616	0.335		0.245
8028.505	-1.515	0.634	0.344	0.263	0.264
8029.479	-1.513	0.614	0.403	0.070	0.224
8030.465	-1.516	0.572	0.330	0.263	0.171
8031.479	-1.520	0.631	0.256	0.374	0.038
8032.479	-1.519	0.611	0.351	0.158	0.161
8033.493	-1.523	0.603	0.388	0.171	0.196
8034.559	-1.532	0.614	0.383	0.280	0.228
8198.830	-1.488	0.653			
8200.805	-1.493	0.623	0.255		0.210
8201.805	-1.504	0.600			0.248
8202.792	-1.498	0.598			0.307
8203.799	-1.509	0.628	0.313	0.363	0.224
8206.840	-1.503	0.625	0.343		0.243
8207.806	-1.503	0.618	0.352		0.291
8208.799	-1.514	0.609	0.368		0.265
8210.809	-1.508	0.618	0.409		0.316
8211.781	-1.499	0.608			0.284
8271.823	-1.514	0.633	0.380	0.260	0.260
8272.802	-1.514	0.654	0.363		0.238
8273.823	-1.502	0.631	0.399	0.201	0.268
8274.823	-1.510	0.629	0.368	0.491	0.261
8275.757	-1.511	0.628	0.375	0.266	0.253
8276.785	-1.509	0.628	0.383	0.342	0.252
8277.771	-1.509	0.609	0.401	0.490	0.278
8278.722	-1.500	0.620	0.355	0.081	0.245
8279.771	-1.522				
8280.823	-1.517	0.622	0.392	0.251	0.262
8281.823	-1.508	0.626	0.393	0.097	0.264
8282.750	-1.515	0.625	0.387	0.045	0.274
8283.802	-1.502	0.624	0.388	0.340	0.268
8284.750	-1.496	0.607	0.367	0.256	0.275
8285.760	-1.499	0.612	0.381	0.451	0.282
8286.763	-1.499	0.626	0.398	0.354	0.280
8287.778	-1.493	0.628	0.332	0.332	0.264
8288.722	-1.490				
8289.778	-1.491				
8290.740	-1.487	0.586	0.439		0.310
8291.743	-1.488	0.652	0.340	0.242	0.235
8292.819	-1.487	0.637	0.379	0.267	0.233
8293.770	-1.492	0.624	0.355	0.393	0.274
8294.688	-1.494	0.606	0.402		0.282
8295.750	-1.490	0.612	0.388	0.232	0.252
8296.844	-1.485	0.616	0.379	0.369	0.275
8297.844	-1.487	0.626	0.370	0.301	0.275
8298.826	-1.479	0.620	0.372	0.266	0.271
8299.840	-1.487	0.620	0.373	0.266	0.269
8300.819	-1.486	0.628	0.376	0.317	0.258
8301.840	-1.488	0.627	0.367	0.326	0.276
8302.826	-1.487	0.630	0.380	0.363	0.261
8307.760	-1.504	0.639	0.388	0.237	0.253
8309.760	-1.509	0.633	0.368	0.302	0.254
8311.760	-1.488	0.612	0.384	0.330	0.290
8312.791	-1.491	0.640	0.407	0.220	0.262
8313.865	-1.498	0.626	0.380	0.356	0.268
8314.865	-1.490	0.609	0.401	0.319	0.286
8315.812	-1.489	0.626	0.394	0.308	0.235
8316.844	-1.474	0.615	0.386	0.233	0.255

$[B-L]/[B-U]$ based on Kurucz (1979) models, were consulted (Lub and Pel 1987; Hoekzema et al. 1992). These diagrams give T_{eff} and log g. The latter is an indication for the luminosity class. Sometimes this method gave a more or less decisive answer, sometimes not. For a few stars two possibilities were used and listed in Table 4; other very doubtful cases were rejected.

From $V-B$ and $(V-B)_0$ (the latter is corrected for the reddening $E(V-B)$), $(B-V)_J$ and $(B-V)_{J0}$, can be obtained, and consequently the reddening $E(B-V)_J$, which is listed in Table 4. With the aid of the extinction law $R = 3.1$ the extinctions were derived and then V_{J0}. Table 4 also lists the estimated spectral types and luminosity classes, derived from the location of the stars in the two-colour diagrams. With the aid of Schmidt-Kaler's (1982) tables, M_{V_J} was derived for each star from the estimated spectral type and luminosity class and the the distance r. Star no. 122 is possibly a supergiant of spectral type B8. Because of the large uncertainty in the luminosity of supergiants this star was omitted. Due to the limiting magnitude of 14.5, Table 4 shows a clear dependance between spectral type and reddening: the cool stars can only be detected to a distance relatively close to the sun, the hot ones, which are absolutely brighter, are therefore detectable to much greater distances.

Table 4. The derived spectral types and reddenings of the stars around WRA 751.

No	Sp		E(B-V)J	No	Sp		E(B-V)J	No	Sp		E(B-V)J
2	K4	V	0.08	41	B8.5	V	0.55	115	B5	V	0.58
3	O4	V	0.54	43	A5:	V	0.19:	116	B6	V	0.54
4	G\K	V	0.10:	44	F4	V	0.02	117	B9:	V:	0.88:
5	B5.5	V	0.45		B7	V	0.31	118	G2	V	0.08
6	B7	V	0.46	45	K1	V	0.04	119	B2.5	V	0.56
7	F6	V	0.11	46	F8	V	0:16	121	F4	V	0.31
8	F3	V	0.33	49	B9	V	0.52	124	B9	V	0.66
	G5:	V:	0:	50	B5	V	0.48	125	B9	V	0.58
10	B5	V	0.43	52	B1.5	V	0.46		A4	V	0.45
11	B4	V	0.44	53	B2	V	0.53	126	K4	V	0.03
13	B7	V	0.45	54	K2	V	0.10	127	B5.5	V	0.54
16	G3	V	0.08	57	K0	V	0	128	G2	V	0
18	G6	V	0.06	58	B2.5	V	0.54	129	A4	V	0.52
19	A4	V	0.24	100	B4.5	V	0.58		B9.5	V	0.67
21	B2.5	V	0.55	101	B3	V	0.81	130	G2:	V:	0.09:
22	A8	V	0.07	102	B4	V	0.63	133	F0	V	0.21
28	F8	V	0.06	104	B6.5	V	0.50	134	B9	V	0.67
32	M	V	0	105	A4	V	0.60	135	K0:	V:	0:
33	F6	V	0.10	106	A3	V	0.32	136	A5	V	0.43
34	B4	V	0.58	107	F0	V	0.21	137	B2	V	0.92
35	B6	V	0.47	108	F4	V	0.12	138	A2	V	0.33
36	F2	V	0.06	109	B1.5	V	0.58	139	B5	V	0.50
37	F5	V	0.19	110	K4:	V:	0.03:	140	B7	V	0.79
38	F8	V	0.09	111	B4	V	0.55	141	G5	V	0
39	A0	V	0.19	112	F8	V	0.11	143	B6	V	0.50
40	A2	V	0.51	113	B1	V	0.58	144	K\M	V	0:
41	F0	V	0.36	114	B1	V	0.61	145	B7	V	0.18

The position of WRA 751 in the two-colour diagrams (using the 1991 data) is only somewhat below the reddening line for O type stars, especially in the $V-B/U-W$ diagram. This means that it is of a high temperature, but perhaps not as high as 30 000 K as advocated by Hu et al. (1990). It is however not possible to give a reliable quantitative number. A precise photometric reddening determination may be hampered by the presence of an extended atmosphere (de Winter et al. 1992) and consequently by a flatter energy distribution. In that case the star should look slightly redder in $V-B$ and $(B-V)_J$ than according to its temperature. The same problem arises in the cases of AG Car (Paper XI) and HR Car (van Genderen et al. 1991). Furthermore, the presence of emission lines makes the colour indices less reliable although Hu et al. (1990) could demonstrate that for the $(B-V)_J$ colour index such an error is likely of the order of $\sim 0\overset{m}{.}01$ only.

Nevertheless to be on the safe side we adopt a lower limit

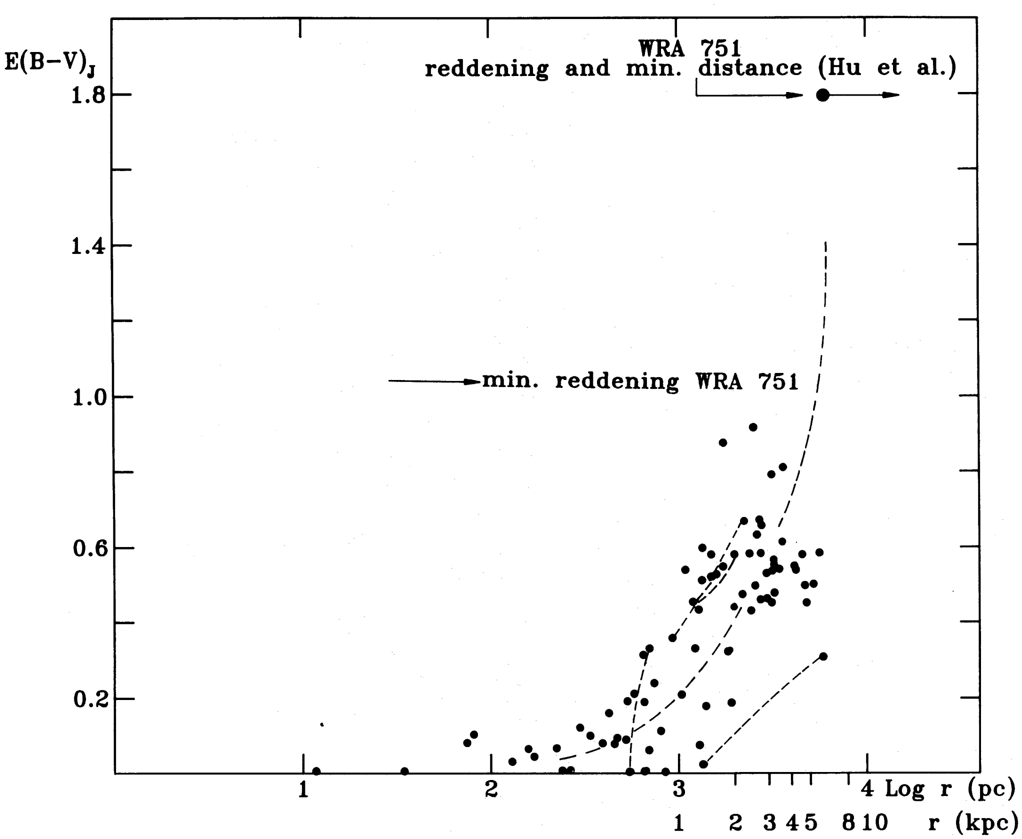

Fig. 2. The reddening-distance diagram of the stars in the field of WRA 751, showing the minimum and maximum values for the interstellar reddening

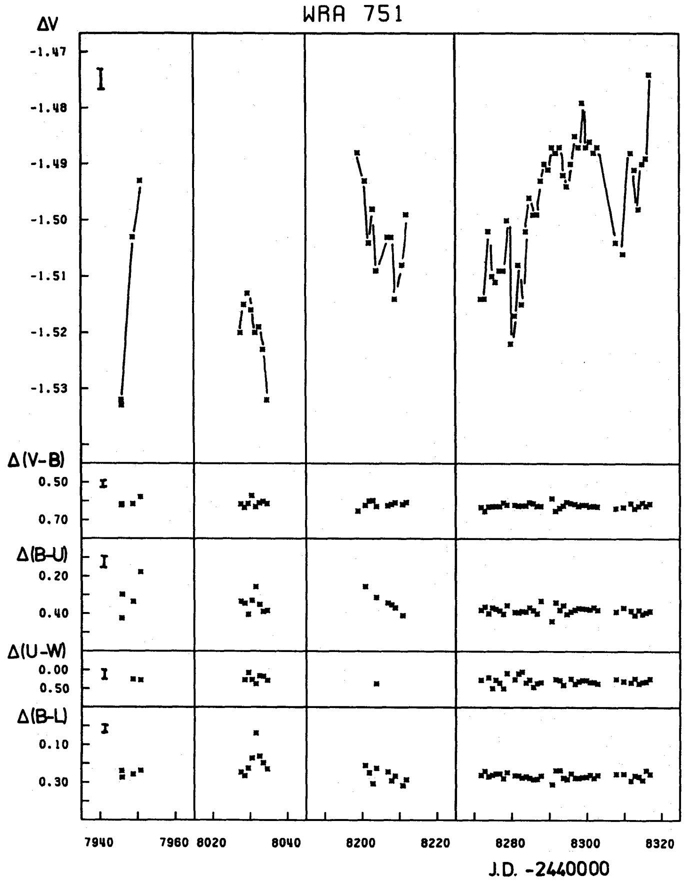

Fig. 3. The nightly averages for brightness and colours of WRA 751 relative to the comparison star, observed in 1990 and 1991 (in log intensity scale) as a function of Julian Date. The error bars represent 2σ for the individual observations

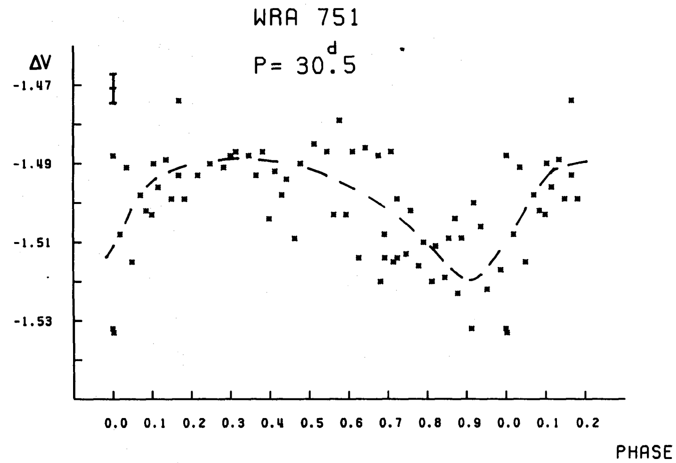

Fig. 4. The phase diagram of WRA 751 for the nightly averages. The error bar represent 2σ for the individual observations

of $E(V-B) = 0.7$ (adopting $\log g \sim 1$) or $E(B-V)_J = 1.^m45$ (interstellar and circumstellar reddening). Since the circumstellar reddening amounts to $\leq 0.^m40$ (improved value of the circumstellar reddening based on the same method of Hu et al. 1990), we derive an absolute minimum value for the interstellar reddening of $1.^m05$. The total reddening obtained by Hu et al. (1990), by fitting the observed spectral energy distribution to a Kurucz model, amounts to $E(B-V)_J = 1.^m8 \pm 0.^m1$. This is equal to the ultimate photometric upper limit, based on the VBLUW photometry, otherwise the position of the unreddened variable should lie at the left of the main sequence in the three two-colour diagrams. Therefore, the total reddening should lie somewhere between these two limits.

4. The reddening-distance diagram

Fig. 2 shows the $E(B-V)_J/\log r$ diagram for most of the measured stars around WRA 751 (r in kpc is also indicated). For a few stars two possiblities were plotted and connected by a dotted line. The average uncertainty in the individual reddening is $\pm 0.^m05$. The smooth eyeball fitted curve to the data points, suggests that WRA 751's distance at the minimum value of the interstellar reddening is ≥ 4 kpc, and on the average ≥ 5 kpc; therefore, Hu et al.ś (1990) distance of ≥ 5 kpc is confirmed.

5. The light variations and the quasi-period

Fig. 3 shows the 1990 and 1991 light and colour curves of WRA 751 relative to the comparison star in log intensity scale as a function of Julian Date. Notice that the scales of the colours are reduced with respect to that of V. The total light range or maximum light amplitude MLA (see section 6) amounts to 0.058 (log intensity scale) or $0.^m15$. No intrinsic colour variation can be detected, mainly due to the relatively large standard deviations. Hot variable supergiants show very small colour variations anyway; in the order of $\leq 0.^m01$ (van Genderen 1991b).

The last panel with the six weeks of monitoring shows a $\sim 30^d$ wave with superimposed on it a number of smaller time scale ($4^d - 8^d$) oscillations with amplitudes of $0.^m02 - 0.^m05$. Remembering the light variations of other variable supergiants, including LBVs, there are two possibilities:

1. The 30^d wave represents the intrinsic variation typical for mid-B type supergiants, often with small irregular variations superimposed on their light curves. This is not in contradiction with the classification of WRA 751 as an LBV, although the many humps and bumps are not typical for LBVs. The light curves of R71, AG Car and HR Car are relatively smooth.

2. The short time scale variation represents the intrinsic variations typical for early B type supergiants superimposed on long time scale variations, which should then be caused by small S Dor eruptions; an increasing mass loss rate causes an increase of the optical depth in the envelope and a rise of the visual brightness. In the case of WRA 751 de Winter et al. (1992) concluded that this star is in a state of quiescence. Another indication for the occurence of small S Dor eruptions is that the colours become somewhat redder. However, for WRA 751 in its minimum-brightness phase these small reddenings lie below the detection limit due to the relatively large errors in the colour-indices. Note that AG Car and HR Car show such a small reddening. (Paper XI, van Genderen 1991a).

In order to investigate a possible long time scale peridiocity in the light variations we used the period search program of Sterken (1977). The search was made between 20^d and 50^d with steps of $0.^d5$. The most significant quasi-period appears to be $\bar{P} = 30.^d5$ with a correlation coefficient $r = 0.625$. Fig. 4 shows the phase diagram. Although the light curves looks convincing, we have to consider the reliability with caution due to the relatively small number of data.

6. The theoretical HR and MLA/log T_{eff} diagrams

Fig. 5 shows the position of WRA 751 in the theoretical HR diagrams, as suggested by Hu et al. (1990) and five other LBVs. For R71, AG Car and HR Car the $\bar{P}$s are given (between brackets), according to Papers VI and XI, and for P Cyg the presumable $\bar{P}$ (van Genderen 1991a) is deduced from de Groot's (1989) light curve. The so obtained quasi-period for P Cyg is not in contradiction with the oscillations exhibited by the light curves discussed by Percy et al. (1988). The position of HD 160529 and its period are taken from Sterken et al. (1991). These five LBVs appear to fit the P = constant lines (oblique dotted lines for 10, 20, 50 and 100^d) according to Maeder (1980) reasonably well. Obviously, WRA 751 with its $\bar{P} = 30\overset{d}{.}5$ does not fit. A shorter time scale oscillation of a week or so would be better, especially if the temperature appears to be somewhat lower than 30 000 K (see section 3). A continuation of the investigation of the distance, temperature, luminosity and variability of WRA 751 is clearly required.

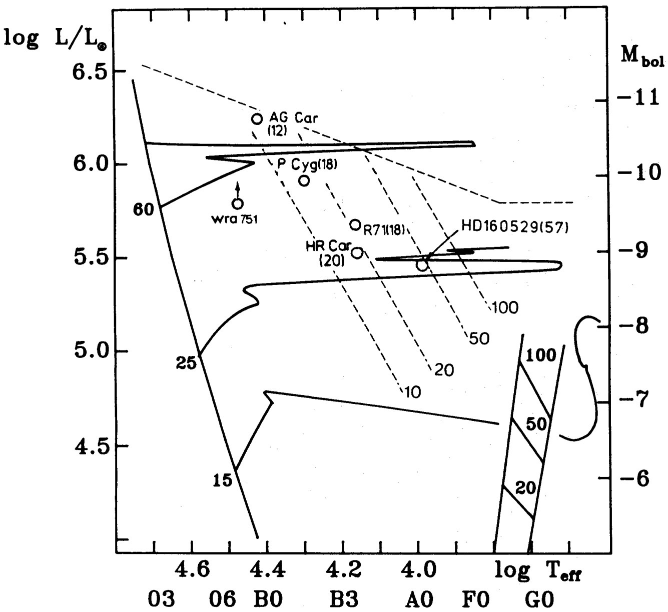

Fig. 5. The position of WRA 751 in the theoretical HR diagram according to Hu et al. (1990) and that of four other hot S Dor type stars (LBVs)

The classification of Hu et al. (1990) and de Winter et al. (1992) that WRA 751 is a new LBV makes it interesting to compare its maximum observed light amplitude (MLA) with that of normal and high mass loss rate supergiants. Fig. 6 shows its position in the MLA versus log T_{eff} diagram according to van Genderen (1989, 1991b). Realizing that due to the low number of observed cycles the observed MLA is likely a lower limit, its position supports the identification of a high mass loss rate object. However, the mass loss rate of $-5.5 < \log \dot{M}_{\odot} < -6.0$, determined by de Winter et al. (1992), is comparable to that of HR Car, but significantly lower than that of AG Car, even when it is at its minimum-brightness phase. This indicates that the temperature of WRA 751 should indeed be somewhat lower than 30 000 K.

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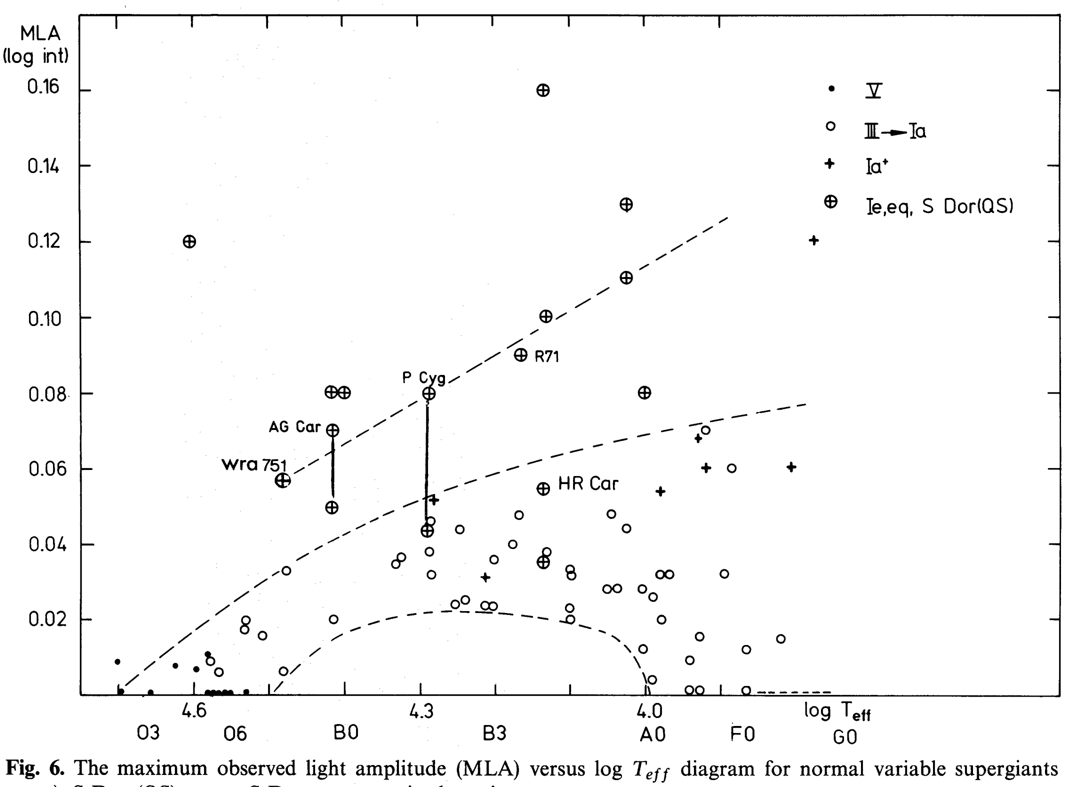

Fig. 6. The maximum observed light amplitude (MLA) versus log T_{eff} diagram for normal variable supergiants (usually below the upper dotted curve). S Dor (QS) means S Dor type stars in the quiescent stage

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