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Notes on the heavily reddened and variable A-type supergiant CD-33°12119*

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Summary. The results of photometric measurements (0.3 to 5 μm) and a spectroscopic study of the variable A2 Ia-type star CD-33°12119 are presented and discussed. The visual brightness variation of the star shows a peak-to-peak amplitude of $\sim 0\overset{m}{.}2$ and a characteristic period of ~35 d. The most striking phenomena of the visual spectrum are the extremely strong P Cygni profiles of Hα and Hβ. The extinction-free spectral energy distribution, up to ~5 μm, fits a theoretical Kurucz LTE model-atmosphere of $T_{\rm eff} = 10{,}000$ K and $\log g = 1.5$ satisfactorily. This is in agreement with the spectral type A2 Ia derived from line strength ratios. Strong interstellar absorption lines occur in the spectrum of CD-33°12119, produced by the same interstellar material which causes a total visual extinction $A_V = 6\overset{m}{.}45$ suffered by the star. It can be shown that the physical parameters obtained from our observations fit the $P-L-C$ relation for variable supergiants derived by Burki (1978) reasonably well. A radial velocity of 30 km s^{-1}, determined using stellar Si II lines, indicates that the star is most probably a run-away object.

Key words: variable stars – supergiants – photometry – spectroscopy – energy distribution

I. Introduction

A preliminary report on *VBLUW* photometry (Walraven system) of the variable A-type supergiant CD-33°12119 (=Henize 1416) was published some years ago (van Genderen and Hammerschlag-Hensberge, 1975). At that time the star was suspected to be the optical counterpart of the X-ray source 3U1727-33. Revisions in the position of the error box of the X-ray source in the 4th Uhuru Catalogue (Forman et al., 1978) now place CD-33°12119 well away from the location of the X-ray source.

CD-33°12119 is a supergiant varying in visual light with an amplitude of $\sim 0\overset{m}{.}2$. The spectrum is peculiar with P Cygni characteristics in the Balmer lines (Krzeminski and Garrison, 1973). Large variable radial velocities have been measured by Hensberge and Zuiderwijk (1975).

The results of *UBV* photometry were discussed by Bord et al. (1977). The "flares" observed by these authors are presumably caused by the presence of a faint blue star situated at a close distance (van Genderen and Hammerschlag-Hensberge, 1975).

In the present paper we discuss additional *VBLUW* photometry together with *VRI* (Cousins system) and *JHKLM* (Johnson system) measurements. We also present the results of visual coudé spectroscopy. It should be noted that these data are not sufficient to study the star CD-33°12119 rigorously. Since it is not our intention to make further observations, we present our data together with some notes for those interested to study the star in the future.

II. The photometric observations

II.1. The *VBLUW* photometry

The *VBLUW* photometry was made in 1975 and 1976 with the Walraven simultaneous photometer attached to the 90-cm lightcollector at the former Leiden Southern Station at the S.A.A.O. annex, South Africa. A description of the photometer and the photometric system is given by Walraven and Walraven (1960), Rijf et al. (1969) and Lub and Pel (1977).

The primary comparison star is SAO 208883. To check its constancy it was compared a few times with SAO 208881 (=HD 158320). Both stars belong to a quintuple system. SAO 208883 is component *D*, whereas SAO 208881 is component *A* (itself a spectroscopic binary). Component *B* is located at a separation of 4″ from *A* ($3^{\rm m}$ fainter than *A*) and component *C* at 15″ from *A* ($5^{\rm m}$ fainter than *A*) (Penny et al., 1975). The contamination of the light of *B* and *C* to that of *A* is negligible when a 23″ diaphragm is used. The four components *A*, *B*, *C*, and *D* are all of spectral type B. During the first few months of 1975 the star CD-33°12119 was observed through a 23″ diaphragm. Therefore most of the observations of the variable are slightly deteriorated by the straylight of a faint $13^{\rm m}$ optical companion located at a separation of 15″. Since it is a blue star, its influence in the blue and ultraviolet light is somewhat larger than in the yellow. To exclude the influence of this star a 15″ diaphragm was used for all observations afterwards. A photometric comparison with standard stars provided the data in the *VBLUW* system. Corrections for differential extinction were applied.

The $V-B$ colour index of the *VBLUW* system (given in log intensity scale) can be transformed into the equivalent $B-V$ index of the *UBV* system (denoted by a subscript *J*) using Table 7 in Walraven et al. (1964); this transformation was revised because of a slight systematic change in the *V* pass-band (Lub and Pel 1977). The V_J (=the *V*-mag. in the *UBV* system) can be transformed from *V* of the *VBLUW* system using a formula given by Pel (1976).

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* Partly based on observations collected at the European Southern Observatory, La Silla, Chile

Table 1. Photometric parameters of CD-33°12119 (*VBLUW* system) in log intensity scale relative to SAO 208883

J.D.- 2440000	ΔV	Δ(V-B)	Δ(B-L)	Δ(B-U)	diaf. (")	n
1960.237	-.350	.791	.168	.464	23	2
1962.239	-.361	.806	.183	.621	15	2
1964.240	-.364	.787	.211	.586	15	5
2543.455	-.382	.815	.206	.508	23	3
2548.420	-.379	.807	.208	.525	23	4
2550.424	-.365	.783	.165	.440	23	4
2552.427	-.379	.821	.208	.543	15	4
2564.302	-.342	.802	.186	.601	23	4
2564.378	-.338	.803	.193	.572	23	3
2567.333	-.328	.799	.208	.579	23	3
2569.323	-.337	.805	.216	.525	23	3
2569.479	-.334	.796	.186	.525	23	7
2573.354	-.342	.803	.206	.535	23	9
2573.389	-.343	.803	.203	.545	23	3
2575.326	-.349	.802	.181	.607	23	7
2579.264	-.352	.808	.194	.561	23	2
2579.458	-.356	.792	.196	.532	23	3
2581.382	-.364	.796	.177	.532	23	2
2581.464	-.361	.796	.182	.544	23	1
2590.250	-.356	.828	.177	.524	23	3
2592.240	-.350	.807	.172	.551	23	3
2592.264	-.356	.810	.177	.524	23	3
2594.271	-.362	.807	.166	.562	23	5
2598.326	-.358	.798	.181	.535	23	2
2598.423	-.352	.801	.188	.520	23	2
2601.285	-.353	.818	.215	.570	23	2
2601.361	-.347	.799	.192	.545	23	2
2602.313	-.341	.795	.214	.531	23	2
2602.403	-.352	.781	.210	.545	23	1
2605.306	-.352	.792	.201	.525	23	2
2605.322	-.352	.802	.165	.519	23	1
2609.264	-.359	.824	.197	.522	23	2
2609.288	-.362	.803	.184	.507	23	1
2609.378	-.355	.784	.205	.530	23	2
2611.278	-.368	.806	.203	.535	23	2
2611.406	-.361	.777	.193	.485	23	2
2613.260	-.365	.807	.221	.569	23	3
2619.226	-.380	.815	.199	.565	23	4
2620.233	-.377	.815	.169	.545	23	4
2622.236	-.371	.807	.132	.609	23	4
2624.281	-.379	.801	.212	.557	23	3
2626.271	-.377	.805	.180	.572	23	4
2629.257	-.383	.804	.188	.502	23	4
2631.271	-.378	.809	.181	.570	23	3
2633.240	-.370	.805	.161	.526	23	4
2633.288	-.365	.785	.180	.608	23	1
2636.253	-.363	.798	.206	.486	23	3
2636.385	-.364	.786	.143	.562	23	2
2638.253	-.363	.797	.215		23	4
2655.219	-.381	.825	.181	.677	15	1
2656.233	-.385	.832	.146	.548	15	4
2660.250	-.377	.824	.191	.588	15	3
2663.222	-.357	.825	.163	.564	15	5
2664.229	-.357	.824	.179	.551	15	3
2665.250	-.360	.812	.202	.547	15	3
2673.236	-.339	.813	.184	.589	15	4
2674.233	-.343	.805	.164	.501	15	4
2676.233	-.340	.811	.141	.559	15	4
2678.229	-.335	.817	.175	.538	15	6
2680.333	-.302	.821	-.007	.572	15	5
2681.229	-.330	.812	.118	.484	15	3
2683.271	-.332	.813	.078	.554	15	5
2685.229	-.336	.815	.171	.572	15	5
2688.233	-.345	.819	.197	.540	15	3
2690.250	-.351	.825	.171	.527	15	4
2692.295	-.359	.809	.143	.526	15	4
2694.281	-.361	.801	.126	.488	15	6
2695.240	-.358	.813	.166	.498	15	4
2696.243	-.364	.813	.141	.499	15	5
2698.247	-.369	.807	.182	.537	15	5
2705.233	-.349	.827			15	6
2712.243	-.355	.805	.164	.628	15	3
2714.250	-.365	.798	.146	.555	15	5
2715.253	-.362	.815	.114	.477	15	6
2720.250	-.387	.800	.137	.549	15	7
2923.378	-.405	.815	.154	.564	15	3
2924.375	-.401	.808	.190	.636	15	4
2930.354	-.383	.818	.167	.572	15	3
2933.441	-.379	.820	.193	.558	15	4
2938.434	-.371	.812	.187	.536	15	3
2946.368	-.359	.806	.138	.516	15	3
2950.438	-.366	.807	.173	.588	15	4
2959.375	-.369	.824	.196	.642	15	2
2962.448	-.392	.821	.146	.604	15	3
2963.406	-.376	.810	.146	.554	15	4
2966.333	-.387	.817	.150	.570	15	5
2974.250	-.386	.809	.160	.477	15	3
2980.226	-.394	.812	.157	.573	15	2
2984.250	-.395	.810	.156	.565	15	5
2986.302	-.390	.813	.160	.560	15	5
2989.257	-.391	.806	.176	.594	15	3
2992.278	-.379	.820	.186	.583	15	3
2993.346	-.381	.807	.201	.516	15	4
2997.243	-.366	.830	.182	.699	15	4
3000.250	-.370	.829	.223	.558	15	2
3003.236	-.375	.818	.189	.604	15	2
3007.243	-.384	.810	.172	.569	15	3
3010.260	-.383	.814	.177	.567	15	2
3018.243	-.369	.817	.136	.536	15	3
3025.250	-.369	.814	.150	.612	15	4
3028.222	-.370	.811	.177	.530	15	4
3032.229	-.373	.815	.130	.561	15	3
3045.302	-.363	.806	.110	.517	15	3
3058.229	-.359	.811	.170	.583	15	2
3063.229	-.358	.803	.119	.528	15	3
3069.240	-.345	.813	.152	.512	15	3
3076.250	-.348	.805	.123	.600	15	4

Table 1 lists the night averages for CD-33°12119 relative to SAO 208883 together with the Julian dates, the diaphragm used and the number of individual observations (*n*). Because of the large scatter in the ultraviolet *W* pass-band, only an average value for the colour index $U-W$ is given in Table 2. The estimated error in this average is ± 0.1. Table 2 tabulates for the variable and the neighbouring stars, just mentioned, the photometric data in the *VBLUW* and *UBV* systems. For the non-variable stars mean errors (m.e.) or estimated errors (e.e.) are added. For comparison purposes, data from other observers are also listed. The agreement is good.

II.2. The VRI and JHKLM photometry

The measurements in the Cousins *VRI* system were made with the 1 m ESO photometric telescope, equipped with an RCA 31034 A (Quantacon) GaAs photomultiplier and filter combinations such as recommended by Bessell (1979). The star CD-33°12119 was measured on three different nights in October 1980. The mean values of V_J (the subscript *J* stands for Johnson), V_J-R and V_J-I are given (in magnitude scale) in Table 3. The estimated internal standard deviations of these values are $\pm 0\overset{m}{.}007$, $\pm 0\overset{m}{.}005$ and $\pm 0\overset{m}{.}004$, respectively. These observations have been made ap-

Table 2. Photometric parameters of CD-33°12119 and neighbouring stars in the *VBLUW* system (in log int. scale) and in the *UBV* system (in mag)

Star	Sp	V	V-B	B-L	B-U	U-W	E_{V-B}	V_J	$(B-V)_J$	$(U-B)_J$	$E_{(B-V)_J}$	Reference	M_V (adopted)	r (pc)
CD-33°12119	A 2 Ia	- 1.410	0.878	0.228	0.689	0.37	0.85	10.25	1.92	-	2.08*	this paper	- 8.0	2300
							±0.05				±0.15		± 0.5	± 600
								10.20	2.1	1.2		Krzeminsky and Garrison (1973)		
								10.20	2.14	-		Bord et al. (1977)		
SAO 208883 (comp. D)	B 3 V	-ᶜ 1.040	0.063	0.058	0.129	0.047	0.13	9.464	0.159	-	0.34	this paper	-2.3	1400
		me ± 0.002	±0.001	±0.002	±0.002	±0.003	±0.03	±0.005	±0.003	-	±0.08		± 0.3	± 220
SAO 208881 = HD 158320 (comp. A including B and C)	~B O	0.076	0.060	0.012	0.018	0.023	0.13	6.674	0.142	-	0.34	this paper	-5.2	1460
		me ±0.003	±0.002	±0.003	±0.003	±0.004	±0.03	±0.008	±0.005	-	±0.08		± 0.3	± 220
	B 0.5II							6.67	0.138	-0.787		Jones et al. (1974)		
	B 0.5III							6.665	0.141	-0.762	0.39	Penny et al. (1975)		
Optical comp. of CD-33°12119	~A5 V	- 2.476	0.16	0.27	0.61	-	0.15	13.04	0.38	-	0.32	this paper	+2.0	1020
		ee± 0.020	±0.03	±0.05	±0.10	-	± 0.05	± 0.05	±0.08	-	±0.12		± 0.5	± 220
								13.04	0.43	0.36		Warren (1975)		

* See section 5.

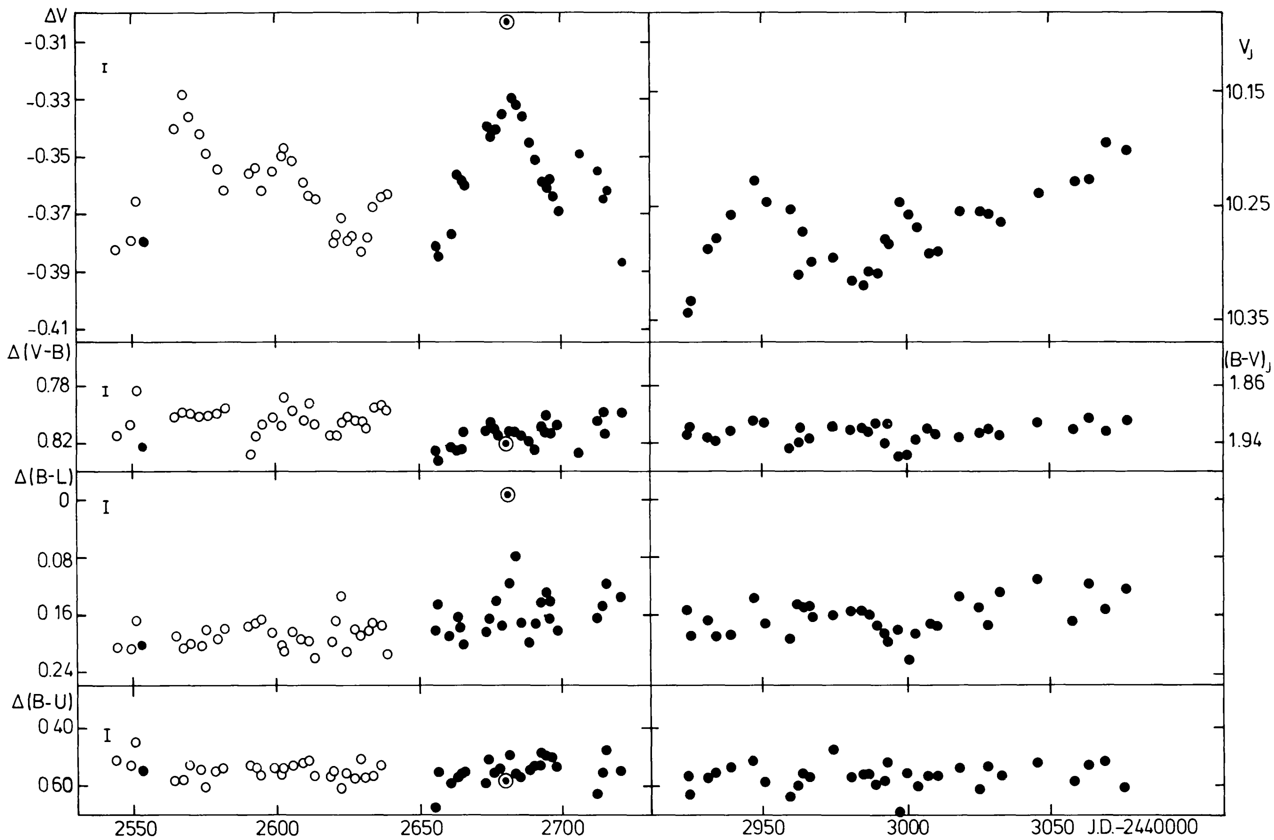

Fig. 1. The light and colour curves of CD-33°12119 relative to the comparison star (in $\log_{10}$ intensity scale). At the right hand side the V_J and $(B-V)_J$ of the Johnson *UBV* system are also given in magnitude scale. The bars at the left top corners denote the mean value of the standard deviations of the night averages. Note that the scales for $\Delta(V-B)$ and $\Delta(B-L)$ are reduced by a factor of 2 and for $\Delta(B-U)$ by a factor of 10 compared to that of ΔV. Open circles and dots are observations made with a 23″ and 15″ diaphragm, respectively

parently at the time when the star was at least $0^m.1$ brighter than the average brightness during 1975/76 (compare V_J in Table 3 with that in Table 2 and Fig. 1).

The *JHKLM* measurements were made with the same telescope. The infrared instrument used is the standard ESO InSb photometer cooled with liquid nitrogen. Unfortunately only one measurement could be made. The results are listed in Table 3. The

Table 3. Photometric parameters of CD-33°12119 in the *VRI* and *JHKLM* systems (in mag)

V_J	V_J-R	V_J-I	n	J	H	K	L	M	n
10.129	1.441	2.820	3	5.44	4.71	4.23	3.84	3.75	1

star CD-33°12119 is so bright in the near-infrared, that we believe that the standard deviation of this one observation is approximately $\pm 0\overset{\mathrm{m}}{.}05$ at each pass-band, such as estimated from multiple measurements of other programme stars.

II.3. The UBV data

The *UBV* data used in this paper are a combination of those obtained by Krzeminski and Garrison (1973) and Bord et al. (1977).

III. The light and colour curves

Figure 1 shows the light and colour curves (in log intensity scale). At the right hand side the scales for V_J and $(B-V)_J$ (in magnitude) are indicated. The error bars at the left indicate the size of the standard deviation of the night averages. Observations made with the 23″ diaphragm are indicated by open circles; they are contaminated by straylight of the blue optical companion. The colour indices are therefore perhaps slightly too blue (thus slightly shifted upwards in the diagrams). The colour-index $V-B$ shows indeed a systematic shift to the blue by $0\overset{\mathrm{m}}{.}02$ with respect to the observations made with the 15″ diaphragm.

The total peak-to-peak light variation is $\sim 0\overset{\mathrm{m}}{.}2$, which is rather large when compared with other variable A-type supergiants (Sterken, 1977; Rufener et al., 1978; Maeder, 1980). The maximum and minimum brightnesses are not constant. The light curves of Rufener et al. (1978) show the same characteristics. The time duration between the seven identified maxima varies between 25 and 50 d, with an average semi-period or characteristic time of ~35 d.

The scatter in the colour curves is too large to show a clear correlation with the light curve. Real colour variations should be smaller than $0\overset{\mathrm{m}}{.}02$–$0\overset{\mathrm{m}}{.}03$. Colour variations of this order and smaller were reported by Sterken (1977) and Rufener et al. (1978).

A remarkable observation, indicating a variability on a time scale of 1–2 d, has been made on JD 2442680 (the encircled dots in Fig. 1). The luminosity increased with $\sim 0\overset{\mathrm{m}}{.}08$ in *V*, *B*, and *U* and with $\sim 0\overset{\mathrm{m}}{.}4$ in *L* (this band is situated near the Balmer limit: $\lambda_{\mathrm{eff}} \sim 3840$ Å). This phenomenon seems to be real, since it is based on five individual observations of the variable alternated by the comparison star, while the standard deviation is equal to the average standard deviation of the other observations.

IV. The spectroscopic observations

Table 4 lists our observational material, obtained with the coudé spectrograph attached to the $1\overset{\mathrm{m}}{.}5$ telescope of the ESO, La Silla, Chile. Rather long exposure times were needed for this faint heavily reddened object, especially in the blue spectral region. In Fig. 2a–e a rectified intensity tracing of the spectrum in the region

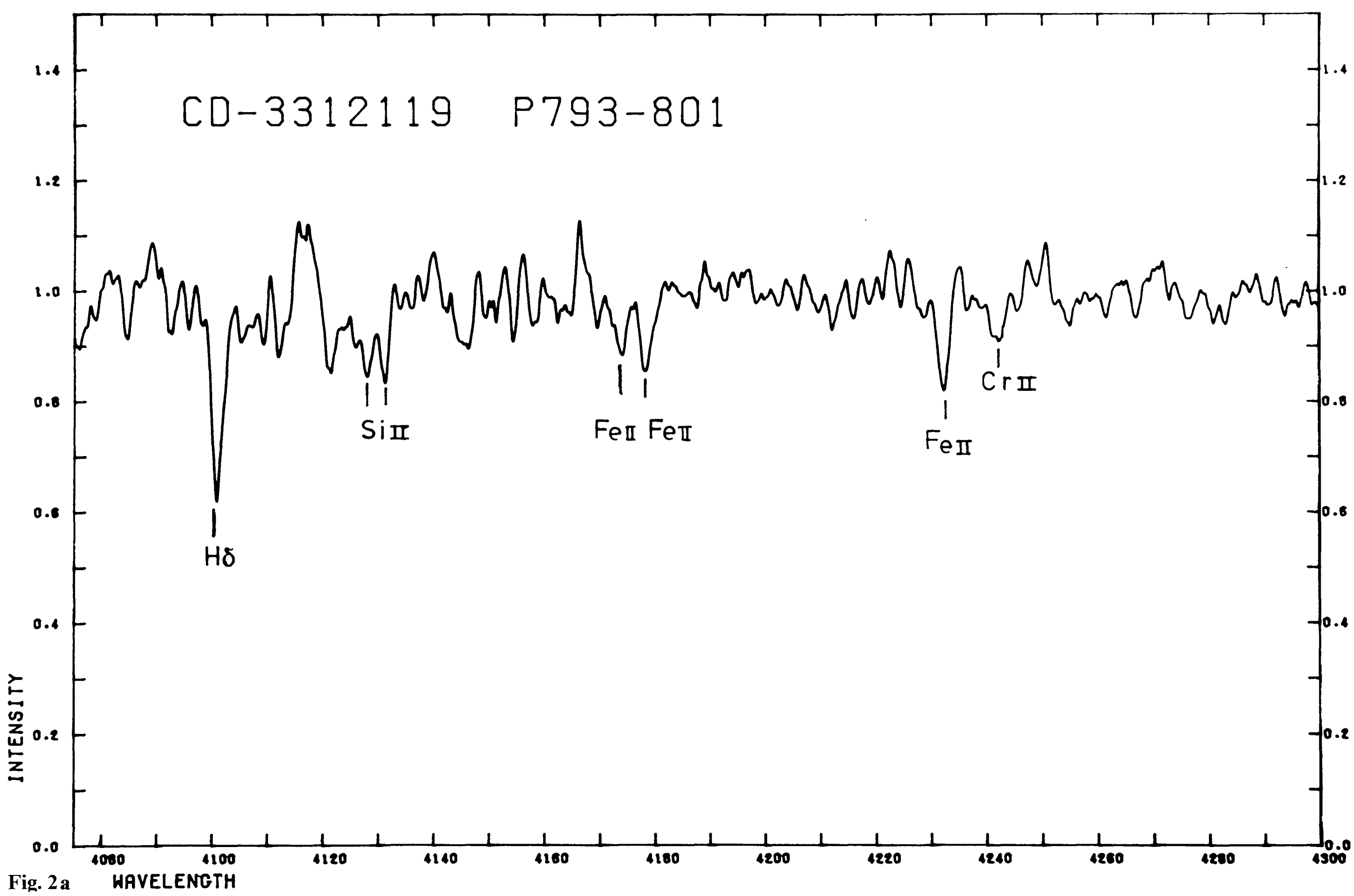

Fig. 2a

Fig. 2a–e. Intensity spectrograms of CD-33°12119 for different parts of the wavelength region λ4080–6700 Å. The continuum level is normalized to 1.0 and some of the most important spectral features are identified

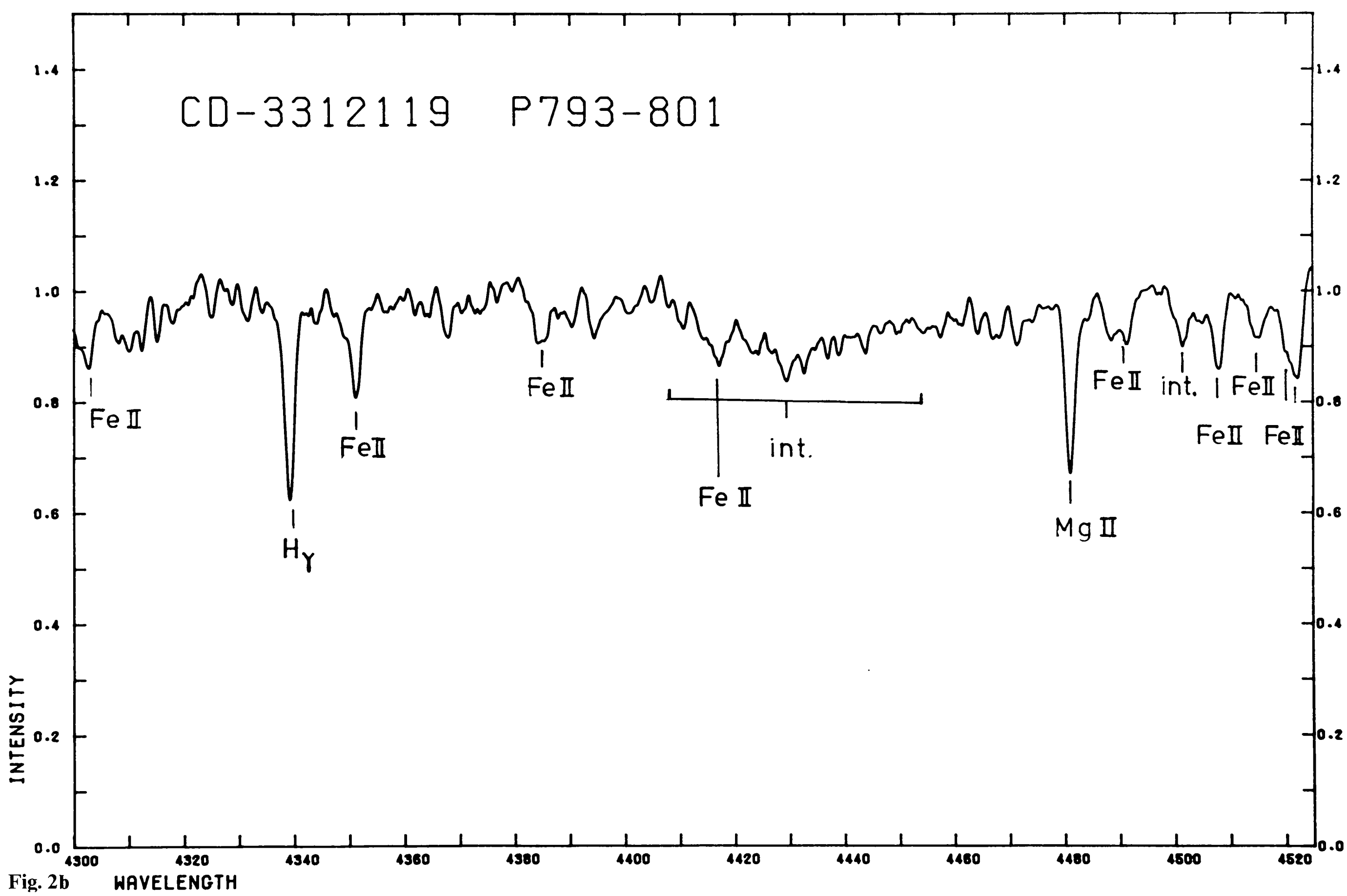
CD-3312119 P793-801
INTENSITY
WAVELENGTH
Fe II
H γ
Fe II
Fe II
Fe II
int.
Mg II
Fe II
int.
Fe II
Fe II
Fe II

Fig. 2b

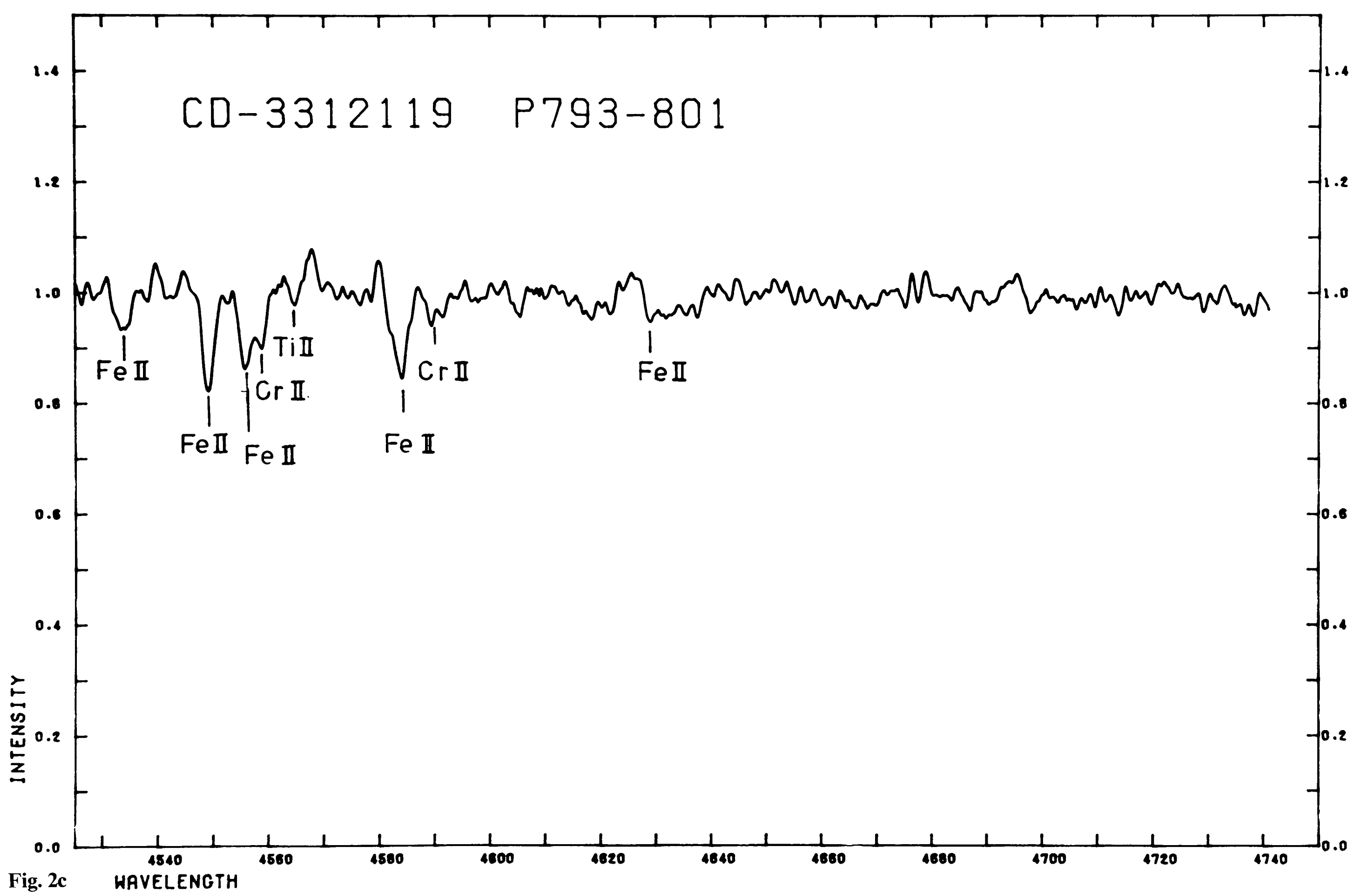
CD-3312119 P793-801
INTENSITY
WAVELENGTH
Fe II
Fe II
Fe II
Cr II
Ti II
Fe II
Cr II
Fe II

Fig. 2c

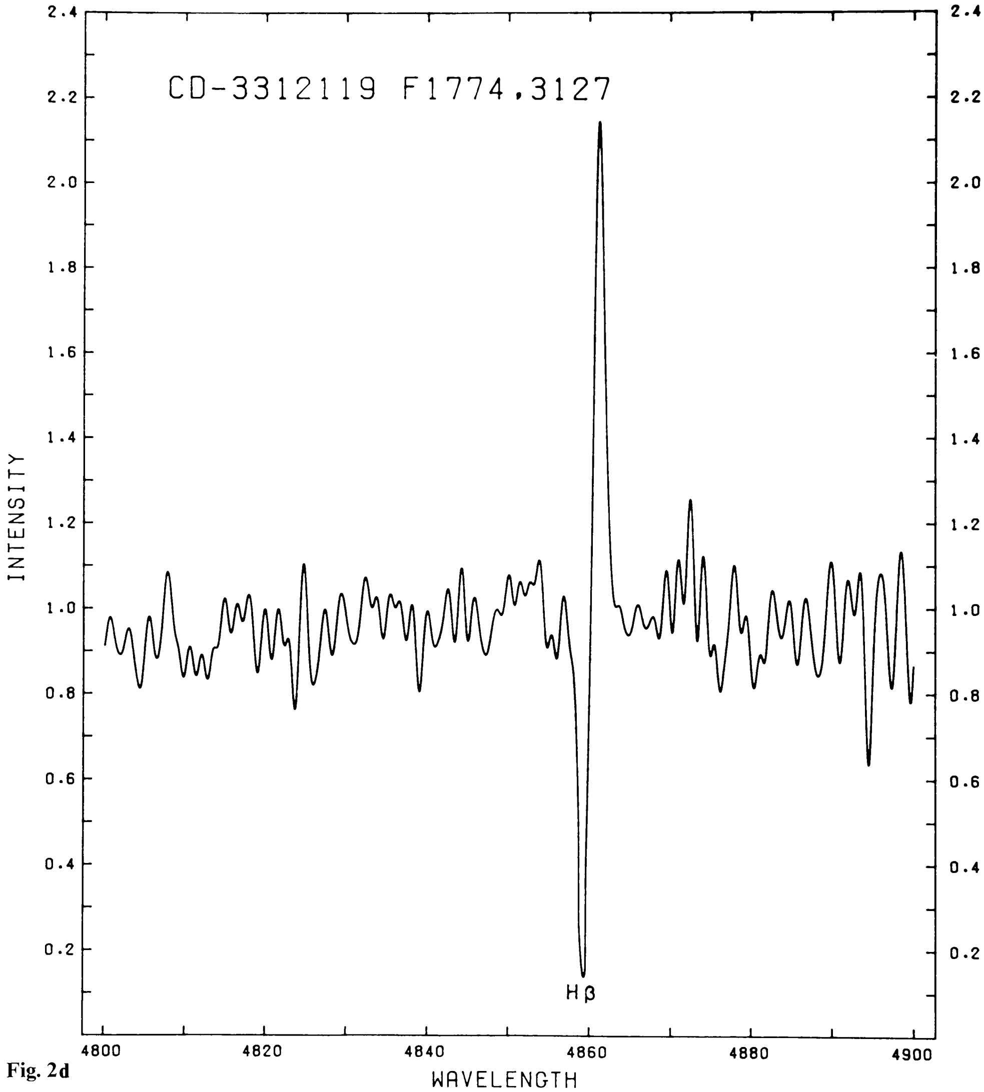
CD-3312119 F1774,3127
INTENSITY
WAVELENGTH
Hβ
4800
4820
4840
4860
4880
4900
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4

Fig. 2d

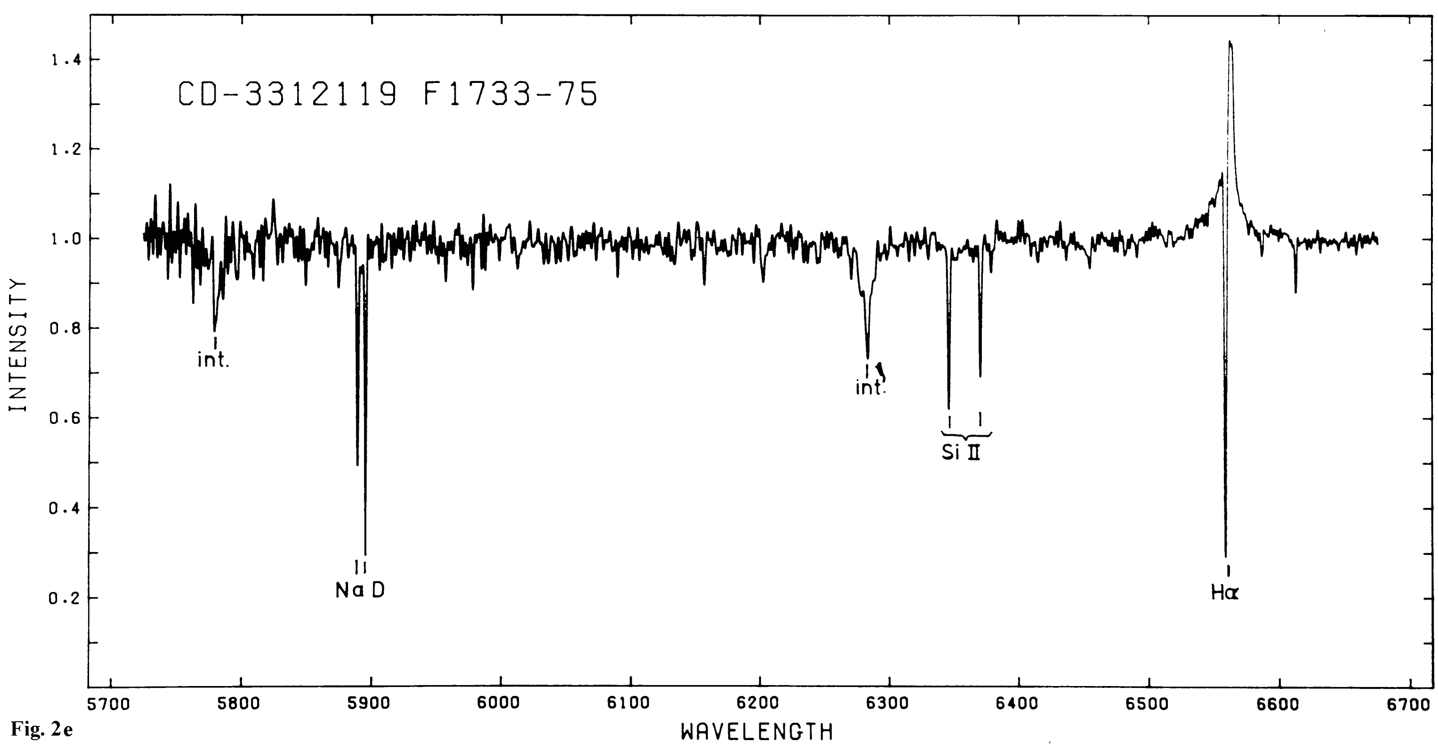
CD-3312119 F1733-75
INTENSITY
WAVELENGTH
int.
Na D
int.
Si II
Hα
5700
5800
5900
6000
6100
6200
6300
6400
6500
6600
6700
0.2
0.4
0.6
0.8
1.0
1.2
1.4

Fig. 2e

Table 4. Logbook of spectroscopic observations of CD-33°12119

Plate no.	Date	Hel JD– 2.440000	Disp Å mm^{-1}	Emulsion	Exp. time
F 1699	May 2 1974	2170.74	31	103aF	1^h32^m
1720	May 6	2174.78	20	IIaO	3 12
1732	May 7	2175.76	20	IIaO	2 00
1733	May 7	2175.83	31	103aF	1 13
1745	May 8	2176.78	20	103aD	2 20
1746	May 8	2176.87	31	103aF	1 44
1774	May 12	2180.85	20	IIaO	2 36
1775	May 12	2180.88	31	103aF	1 53
3119	May 27 1975	2560.84	30	098–02	1 35
3127	June 2	2566.84	20	IIaO	4 00
3134	June 3	2567.90	30	098–02	0 27
3136	June 5	2569.79	20	IIaD	5 00

λ 4075–6700 Å is shown. To reduce the noise we added all the blue (IIaO) and all the red (103aF) spectra: this method gives a much better quality than a single spectrum and makes the identification of spectral lines more easy. The strength of the interstellar lines (indicated by int. in the figures) is very striking. The stellar Hα emission is saturated on all well-exposed plates, so that no detailed analysis of the Hα line profile is possible. We obtained one underexposed plate (F3134) which indicates that the Hα emission is at least as high as 5 times the continuum level. We also note underlaying broad emission wings (28 Å wide).

The observations confirm the presence of strong PCygni lines of Hα and Hβ first noted by Krzeminski and Garrison (1973). Only the rare super-luminous A-type supergiants show this kind of emission. In fact, the spectrum very closely resembles that of HD 7583, which is the brightest supergiant of the Small Magellanic Cloud and for which $M_V \sim -8\overset{m}{.}8$ (Wolf 1973). We argue that CD-33°12119 is also very luminous. From line strength ratios we derive a spectral type A2 Ia.

The strong interstellar lines (λ 6284, 4430 Å) indicate a high interstellar extinction: $W_\lambda(4430) = 4.0$ Å and $W_\lambda(6284) = 2.3$ Å. The ratio between these equivalent widths agrees very well with the empirical relation given by Tüg and Schmidt-Kaler (1981). From their relation between $W_\lambda(4430)$ and $E(B-V)_J$ we find a colour excess of $E(B-V)_J = 1\overset{m}{.}6 \pm 0\overset{m}{.}5$.

The narrow stellar Si II lines are suitable for radial velocity measurements. The three red plates taken on May 7, 8, and 12, 1974 do not show any velocity variation. We derive $v_{star} \sim v_{Si\,II} = 30 \pm 5$ km s^{-1} at $\lambda = 6350$ Å. Because of the large noise in the individual spectra, it is not possible to find more lines suitable for radial velocity determinations. The radial velocity of Hα (absorption) is -47 ± 5 km s^{-1} which is consistent with the model of an expanding stellar atmosphere. No radial velocity variations were detected in our observational material. This is to be expected since all the observations were made within 5 d. It should be noted, however, that Hensberge and Zuiderwijk (1975) already mentioned a large velocity shift for the Hα absorption component between May 1974 and May 1975. This velocity variation needs to be investigated further before drawing any conclusions.

V. The spectral energy distribution

For the determination of the spectral energy distribution it is necessary to investigate the foreground extinction. In Sect. IV we derived a colour excess of $E(B-V)_J = 1\overset{m}{.}6 \pm 0\overset{m}{.}5$ from the strong interstellar lines at λ 4430 Å.

The colour excess can also be obtained from the *VBLUW* observations. In Fig. 3 three two-colour diagrams in this photometric system are shown. The full lines represent the intrinsic two-colour diagrams for main-sequence stars. The arrows indicate the reddening directions and the dotted lines parts of black body curves. In Fig. 3b the intrinsic two-colour diagram for Ia supergiants is also given. The position of CD-33°12119 in these diagrams is shown. The positions of SAO 208883 (comp. *D*) and SAO 208881 (comp. *A* including components *B* and *C*) confirm that they are of early B-type (Penny et al., 1975). The faint optical companion of CD-33°12119 (see Fig. 3a and b) is presumably a

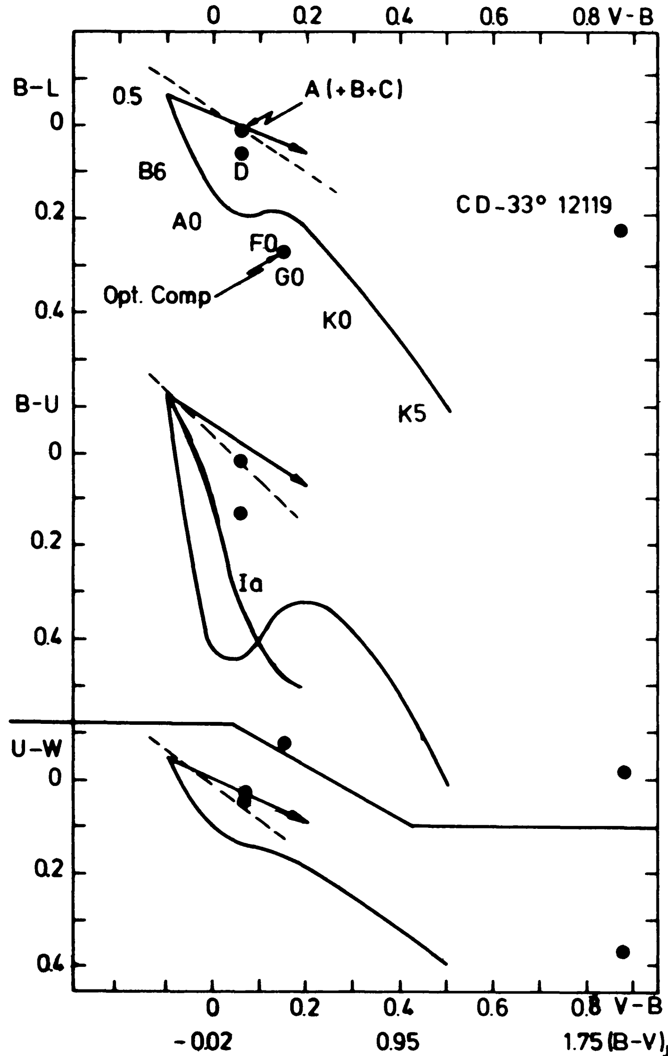

Fig. 3. The three two-colour diagrams in the *VBLUW* system (in $\log_{10}$ intensity scale). For comparison purposes we also show the $(B-V)_J$ index of the *UBV* system (in magnitude scale) along the horizontal axis. The thick drawn curves represent the intrinsic two-colour diagrams of main sequence stars, the arrows indicate the reddening directions and the dotted lines the relation for black bodies. In Fig. 3b the position of the intrinsic two-colour diagram for Ia supergiants is also indicated. The positions of CD-33°12119 and the neighbouring stars are given

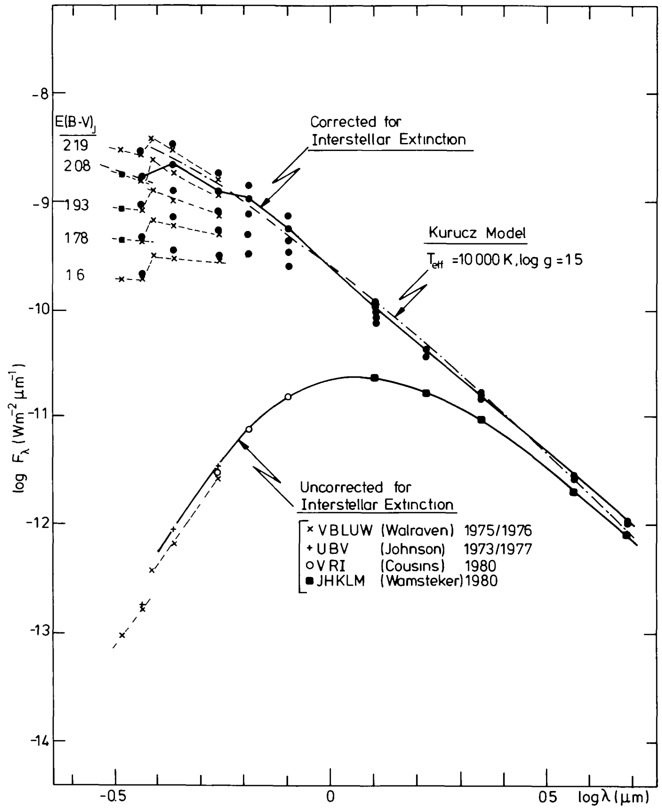

Fig. 4. The spectral energy distribution of the star CD-33°12119. The lower curve is uncorrected for foreground interstellar extinction. The different symbols indicate the various photometric systems used. The upper curves are those corrected for foreground interstellar extinction for different values of the reddening $E(B-V)_J$: 1.6, 1.78, 1.93, 2.08, and 2.19, and based on $R=3.1$. The extinction-free spectral energy distribution for $E(B-V)_J=2.08$ is indicated by the thick line. The spectral energy distribution of Kurucz's model for $T_{\rm eff}=10{,}000$ K and $\log g=1.5$ (indicated by the dash-dotted line) fits this curve best

slightly reddened main-sequence star of spectral type ~A5. The colour excess of CD-33°12119 has been determined using the intrinsic $V-B$ versus $B-U$ diagram for Ia supergiants (see Fig. 3b). Unfortunately, the location of this diagram is known only with an accuracy of ±0.05. We find $E(V-B)=0^{\rm m}85\pm0^{\rm m}05$ in $\log_{10}$ intensity units. This value can be transformed to the UBV system using the relation: $E(B-V)_J=2.58\ E(V-B)=2^{\rm m}19\pm0^{\rm m}13$, which has been derived using the normal extinction law defined by the well known Van de Hulst curve No. 15 (see also Johnson, 1968). This reddening value is much higher than that derived using the interstellar line at λ4430 Å. However, the error expected in the latter ($\pm0^{\rm m}5$) makes agreement between results of the two methods not impossible. In our study of the spectral energy distribution of CD-33°12119 several $E(B-V)_J$ values, ranging from $1^{\rm m}6$ to $2^{\rm m}19$, will be considered.

The influence of the Balmer emission lines on the observed stellar fluxes will now be discussed. The very strong Hα emission influences perceptibly the measured flux through the R pass-band. A rough estimate shows that the R magnitude is about $0^{\rm m}04$ too bright, consequently we corrected it for this effect. Note that the Hα emission does not influence the I magnitude. The Hβ emission does not have any influence on the Walraven V nor the B pass-band, because the position of Hβ is just in between these two pass-bands where their sensitivity is almost zero (see Lub and Pel, 1977). Furthermore, we have ignored the very small influence of the Hβ-emission in the Johnson B and V broad pass-bands. Note that Hγ and Hδ are not in emission. If the absorption part would be marginally filled in by emission, the influence in the B pass-band would still be negligible. In the $V-B$ versus $B-L$ diagram (Fig. 3a) the position of CD-33°12119 is too high. This is perhaps caused by the cumulative effect of the partly filling in by emission of the higher Balmer absorption lines in the measured flux through the L pass-band which has a $\lambda_{\rm eff}=3840$ Å close to the Balmer limit. The amount of this L-excess can be determined using the data of 8 other A Ia supergiants, observed in the $VBLUW$ system by Pel (1976). The result is an excess of ~0.12 in $\log_{10}$ intensity units. This correction is applied to our L measurements. The Walraven U and W pass-bands do not suffer from the effect of emission lines.

After the correction of the observed magnitudes through the various pass-bands for foreground extinction (adopting $R=3.1$), they are transformed to absolute fluxes. The $VBLUW$ measurements were transformed using calibration constants by Lub (1980). The UBV, VRI, and $JHKLM$ magnitudes were transformed using calibration constants published by Johnson (1966), Bessell (1979) and Wamsteker (1981), respectively. The results, together with the spectral energy distribution uncorrected for foreground extinction, are depicted in Fig. 4. The different curves are corrected for extinction, using different values of $E(B-V)_J$. Note that the fluxes obtained from the various photometric systems do not fit together nicely. This is due to the fact that the observations of this variable star were not done simultaneously in the different photometric systems.

Despite these imperfections, several important characteristics of the spectral energy distribution of the star CD-33°12119 can be noted. The estimated spectral type of an A2 Ia supergiant makes it reasonable to assume that $T_{\rm eff}=10{,}000$ K and $\log g=1.5$. This assumption does not contradict the results obtained by Sterken (1976) for early A I-type supergiants; he found that for this type of stars $9700\,{\rm K}\leqq T_{\rm eff}\leqq 10{,}800$ K and $\log g\sim1.2$. When a Kurucz (1979) model of $T_{\rm eff}=10{,}000$ K and $\log g=1.5$ is implemented in Fig. 4 (dash-dotted curve) it is clear that this theoretical curve fits the observed one best for $E(B-V)_J=2^{\rm m}08$; we adopt this value in our further discussion. It means that the value of $E(B-V)_J=1^{\rm m}6$ obtained by means of the interstellar line at $\lambda=4430$ Å is underestimated, and that the value of $E(B-V)_J=2^{\rm m}19$ obtained from the two-colour diagram is somewhat overestimated.

VI. Discussion

Due to the fact that the photometric data in the different pass-bands were not obtained simultaneously, and the uncertainty in the foreground extinction correction, it is not possible to decide about the existence of excess radiation in the near infrared spectral region. The fit of the Kurucz model of $T_{\rm eff}=10{,}000$ K and $\log g=1.5$ to the spectral energy distributions in Fig. 4 is only presented in order to indicate an approximate value of $E(B-V)_J$.

According to the semi-period-luminosity relation for supergiants (Burki, 1978; Maeder, 1980) one should expect that CD-33°12119 has an absolute visual magnitude $M_V=-8^{\rm m}0\pm0^{\rm m}5$. Such a high luminosity is consistent with the presence of strong Balmer-line emission with P Cygni profiles (van Genderen et al., 1982). Other galactic A-type variable supergiants similar to

CD-33°12119 are HD 12953 (Al Ia, 35 d, $-8^m_.0$), HD 14489 (A2 Ia, 34 d, $-7^m_.4$) and HD 378 (A5 Ia, 36 d, $-7^m_.7$) (see Rufener et al., 1978). The absolute magnitude of $-8^m_.0$ adopted for CD-33°12119 is thus not exceptionally large.

It is of interest to study whether our observational results fit the semi-empirical $P-L-C$ relation

$$\log P = -0.346\,M_{\rm bol} - 3\log T_{\rm eff} + 10.60$$

derived by Maeder (1980, Appendix). Since the bolometric correction for a supergiant with $T_{\rm eff} = 10{,}000$ K is $\sim -0^m_.2$ (Allen, 1976), $M_{\rm bol} \sim -8^m_.2$, entailing a $\log P \sim 1.44$. Thus $P \sim 28$ d, reasonably close to the average semi-period of ~ 35 d, mentioned in Sect. III.

The total visual extinction – adopting $R = 3.1$ – amounts to $A_{V_J} = 6^m_.45$. Thus the true visual magnitude $V_{J_o} = 3^m_.80$. Using $M_V = -8^m_.0 \pm 0^m_.5$, a distance of $r = 2.3 \pm 0.6$ kpc can then be derived. This means that the extinction in the direction of CD-33°12119 ($l = 354°$; $b = 0°$) is $\sim 2^m_.8\,{\rm kpc}^{-1}$. This is higher than is normally accepted for directions in the galactic plane: $1^m_.5$ to $2^m_.0\,{\rm kpc}^{-1}$. It is of interest to note that Neckel and Klare's (1980) study of the distribution of dust clouds in the galactic plane within 3 kpc from the Sun also indicates an extremely high interstellar extinction towards the direction of CD-33°12119. From their Fig. 9a one can see that in this direction the maximum interstellar extinction $A_{V_J} \geqq 3^m_.0\,{\rm kpc}^{-1}$.

Finally, it is of interest to consider the radial velocity of the star CD-33°12119. In Sect. IV we explained how the abnormal large radial velocity of $+30\,{\rm km\,s}^{-1}$ has been derived. Due to the galactic rotation the star should approach us with a velocity $v_r = -14\,{\rm km\,s}^{-1}$, derived from $v_r = 2Ar\sin 2l$ and $A = 15$ km ${\rm s}^{-1}\,{\rm kpc}^{-1}$. We therefore argue that the star CD-33°12119 is probably a runaway object.

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