ASTRONOMY & ASTROPHYSICS
SUPPLEMENT SERIES

Astron. Astrophys. Suppl. Ser. **136**, 53–58 (1999)

B[e] stars

VII. MWC 17*

C. Jaschek[1] **and Y. Andrillat**[2,**]

[1] Observatoire de Strasbourg, URA 1280, CNRS, 11 rue de l'Université, 67000 Strasbourg, France
[2] Laboratoire d'Astronomie, Université de Montpellier 2, URA 1280 CNRS, Place Eugène Bataillon, 34095 Montpellier, Cedex 5, France

Received October 29; accepted November 23, 1998

Abstract. On the basis of spectroscopic CCD material obtained at the Haute Provence Observatory, we provide line identifications and equivalent width measurements in the wavelength region 4086 − 8780 Å of the spectrum of MWC 17. Four hundred emission features are identified and seventeen absorption features. Six interstellar bands could be identified. Some of the remaining absorption lines correspond to an early B type star. The emission lines of the envelope correspond approximately to a spectrum of an A0 type star.

The star presents variations in the equivalent widths of its lines which correspond to a factor of about two over a time scale of days.

Key words: stars: emission line, B[e]; MWC17; variables stars: peculiar

1. Introduction

The star was discovered by Merrill & Burwell (1933) who mention its spectrum as "pec". In the notes they add that "*the bright lines are extraordinarily intense and include forbidden lines of ionized iron as in eta Car. The nebular line* λ *4658 also is bright*". Allen (1973) detected a large infrared excess. No radio flux was measurable by Sistla & Seung (1975); Altenhoff et al. (1976), Woodsworth & Hughes (1977) neither at 10.7 GHz, nor at 5 GHz. Ciatti et al. (1974) and Leibowitz (1977) gave detailed descriptions of the spectrum.

Ciatti et al. (1974) mention strong lines of Balmer and Paschen series, OI 8446 (much stronger than λ7774 and the Paschen lines), permitted and forbidden lines of Fe II, [O I] 6300, [S II] 4068. Strong emissions of He I of the triplet system ($\lambda\lambda$4026, 4120, 4471, 5876, 7065, 10830) and of the singlet (λ4387, 6678) and of Ca II (M.2) are also observed, as well as [O II] 7318-30, [Fe III] and [N II] (5755 and faint 6584). They also suggest that the spectrum of a late type companion (type M) might be present.

Leibowitz (1977) analysed low dispersion spectra in the range 3600 − 8500 and provided a list of line identifications which include besides the elements noted by Ciatti et al. (1974) a number of other elements. He estimates the type of the underlying star as O 9 − 9.5.

The star was also observed by Andrillat & Swings (1976) in the 7500 − 12000 region but at rather low dispersion.

An analysis of the Hα width by Swings & Andrillat (1981) lead to the following values: Hα 240 km s^{-1}, wings up to 2000 km s^{-1}; [N II] 210 and 300 km s^{-1} respectively.

The star was also observed spectrophotometrically by Swings (1981) who found strong emissions of P7, Hα, Hβ and Hγ, as well as of Fe II 9277 and [S III] 9069.

Gravina (1982) observed the star at 93 Å/mm at Hγ and found variations in the different emission features over four nights which can be up to a factor of five. Martel & Gravina (1985a) observed the star again in 1985 and found $V = 11.66$, $B-V = +0.42$ and $U-B = -0.20$. They also analyzed the emission line spectrum the same year (Martel & Gravina 1985b) and found among the emissions present [Fe III] 4658 and [O III] 5007. Strafella et al. (1987) found in the K band a variability of more than one magnitude. Allen & Swings (1976) showed that the star had an important infrared excess.

Finally Thé et al. (1994) classified the star as B[e].

Send offprint requests to: Y. Andrillat, 17ter rue Adam de Craponne, 34000 Montpellier, France.

* Based on observations obtained at the Haute Provence Observatory (CNRS).

** Table 2 is only available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/Abstract.html

Table 1. Observational material

Date	Region
26-1-98	4086–4907
27-1-98	4887–5708
29-1-98	5585–6406
28-1-98	6270–7091
29-1-98	8061–8882
23-7-93	7983–8415
17-8-91	8370–8780
18-8-91	7590–8000

Dates are given in day-month-(Year-1900). Regions are given in Angström.

2. Material

The star was observed at the Haute Provence Observatory (OHP) of the CNRS in 1998, although some observations had been made in 1991 and 1993. The wavelength regions and dates of observation are given in Table 1.

Most of the observations were made with the 152 cm telescope, in January 1998. The spectrograph used was AURÉLIE (see Gillet et al. 1994) with a Thomson 7832 double bar detector, with 2048 photodiodes ($750 \times 13\ \mu$). The grating used had 300 grooves/mm, blazed at 6000 Å. The original dispersion is 33 Å/mm, with a resolution of 1.3 Å, equivalent to 65 km s^{-1} at 6000 Å.

Calibrations were made with a tungsten lamp for flat field and in wavelength by means of a hollow cathod of thorium and argon for the blue and the red and thorium-neon for the near infrared.

The observations from 1990 to 1993 were made with the CARELEC spectrograph (Lemaitre et al. 1990) mounted on the Coudé focus of the 193 cm telescope. For $\lambda < 6500$ Å a grating with 1200 lines/mm, blazed at 4000 Å was used, which provides a dispersion of 33 Å/mm in the first order. For $\lambda > 6500$ Å a grating with 1200 lines/mm blazed at 7500 Å was used, which provides a dispersion of 33 Å/mm in the first order. The second order was eliminated with a filter OG590. The receiver was a Thomson CCD (512×384 pixels, 23 square microns), with a resolving power of about one Å. The calibration in wavelength was made with Ne, Ar and He lamps and the flat field correction with a tungsten lamp mounted in the spectrograph.

The data were reduced with the software package IHAP developed at ESO and installed at the OHP.

3. Line identification

Based upon this material we have made line identifications in the traditional way, paying both attention to wavelengths and intensities within the multiplets. The identifications were made with the help of the tables of Moore (1959); for Fe II we also used Johansson's (1978) compilation. In addition we have used the Meinel et al. (1969) catalogue for lines which we could not identify (see notes to Table 2). Some contamination with Hγ I from city lights was unavoidable and is signaled in Fig. 1. Also [O I] 6300 and 6363 are surely contaminated by emissions from the night sky.

Part of the material is reproduced in Fig. 1, where also some line identifications are provided.

In our spectra about 400 emission lines and 19 absorption lines are present. The proportion of emission lines identified is 92%, which is about average for line identification work; 61% of all identified emission lines could be identified totally or partially with iron lines.

Of nineteen absorption lines we could identify seven with certain or probable interstellar features (Herbig 1975; Herbig & Leka 1991), namely $\lambda\lambda$6203, 6283, 6363, 6446, 6476, 6614 and 6662. The two Na I lines 5889 and 5895 are probably also interstellar, although a circumstellar origin cannot be excluded. From $\lambda\lambda$6203, 6283 and 6614, one can derive values of 0.8, 3.4 and 0.5 for the $B - V$ excess.

4. Elements present

We identified the following elements through their emission lines, except if otherwise stated.

- **Hydrogen.** Hδ is too near to the plate border to be useful. Hγ is preceded by an emission peak on the violet side, distant 600 km s^{-1}. The line has $W = 26$ Å and a width at the continuum basis of about 700 km s^{-1}. Hβ has a width of 2000 km s^{-1} and $W = 104$ Å. Hα has $W = 1637$ Å and a width of about 11700 km s^{-1}. The Balmer decrement is thus very large.

  The Paschen series is visible at least up to $n = 31$; on the spectrogram of 1993 also $n = 33$ is visible, although not $n = 32$.
- **Helium.** Members of the ^{1}S,^{3}S,^{1}D,^{3}D,^{1}P^0 series are present in the spectrum, but the lines are neither very intense, nor have the series more than the first two or three terms visible.

  The line λ6310 could be attributed to He II, but other lines are missing, so that the identification cannot be regarded as trustworthy.
- **Carbon** is present under the neutral form, with lines from M.6 and 13 and the ionized form with lines from M.2 and 6.
- **Nitrogen.** Numerous lines of neutral nitrogen are present from M.1, 2, 8, 21 and 29, as well as lines from once ionized nitrogen from M.5, 20 and 53. Is also present M.1 from [N II].
- **Oxygen** is present in three ionization stages. Neutral oxygen is represented by lines from M.1, 4, 9, 10, 19, 21, 22, 34 and 102; [O I] with lines from M.1. Ionized oxygen is present with lines from M.19, 24, 35, 42, 48 and 58. [O III] is represented by lines from M.1 and 2.
- **Sodium** is represented by the two lines from M.1 in absorption.

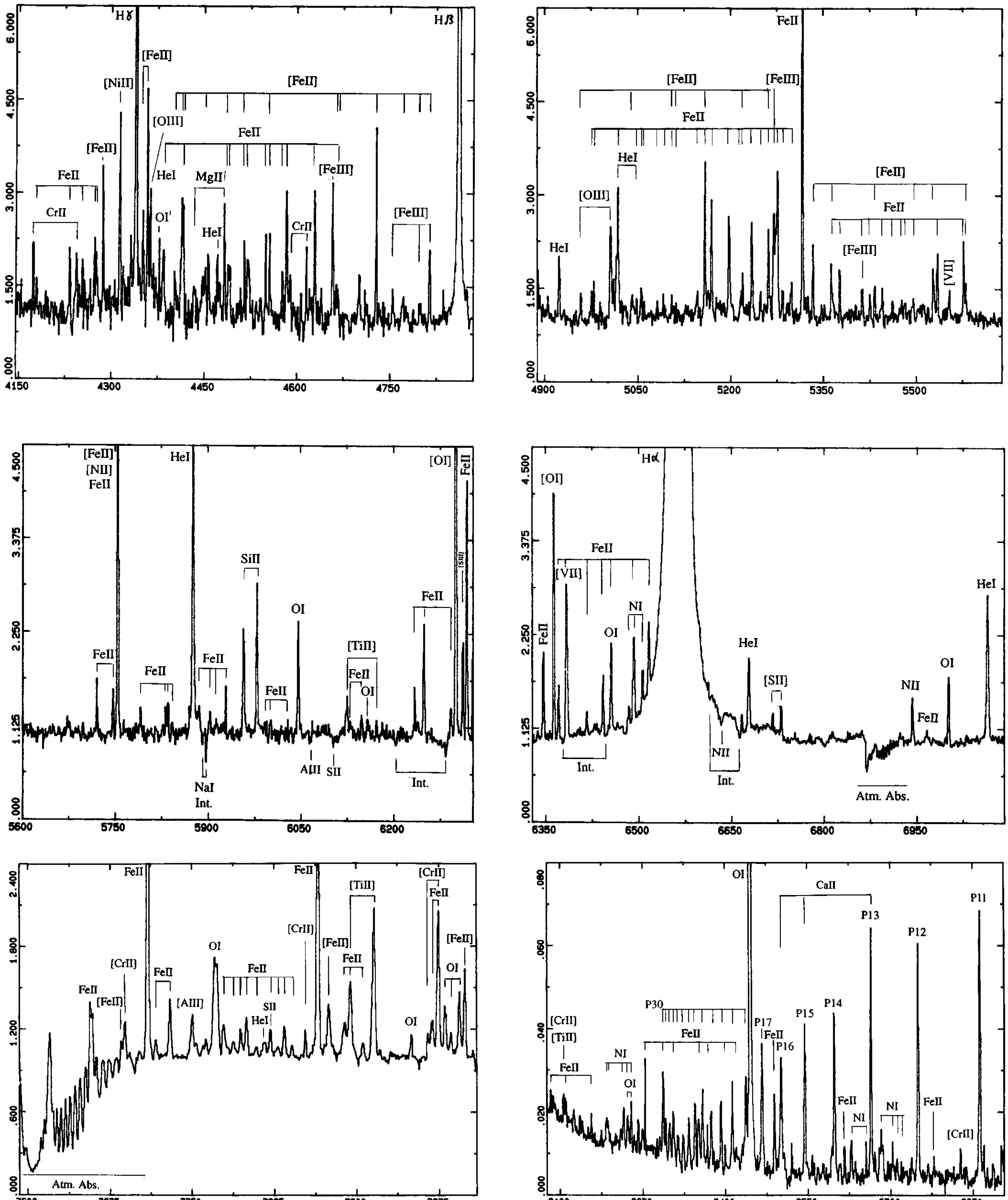

Fig. 1. Reproduction of CCD spectra of MWC 17. Abscissae: wavelengths in Å. Ordinates: intensities. The continuum is set to unity except for the panel at bottom right. Identifications of the most important lines are provided

- **Magnesium** is present in its single ionized form, with lines from M.4, 9, 16, 18 and 27.
- **Aluminium** is represented by lines from M.66, 110 and 116 of singly ionized aluminium.
- **Silicon.** Whereas neutral Si is represented by lines from M.54, singly ionized silicium is represented by lines from M.4 and 8.
- **Sulphur.** Neutral sulphur is present with lines from M.6 and 21, whereas [S I] is present with lines from M.2. Singly ionized sulphur is represented by lines from M.26, 31, 37, 61 and 62 and [SII] by lines from M.2.
- **Calcium** is present in neutral form (M.4) and singly ionized form (M.2).
- **Titanium** is present under the form of Ti II with lines from M.20 and under the form of [Ti II] with lines from M.6, 7, 9, 16, 22, 24, 26, 28 and 39.
- **Vanadium** is only present under the form of [V II] with lines from M.2, 13, 14 and 20.
- **Chromium** is present both in the form of Cr II (M.11, 18, 31 and 44) and of [Cr II] (M.1, 11, 19, 20 and 30).
- **Iron.** Iron lines represent the most frequently found lines- totally or partially they are responsible for 61% of all emission lines. Ionized iron is represented by lines from M.4, 9, 25, 27, 28, 37, 38, 40, 43, 46, 49, 55, 72, 74, 166 and of the non-numbered multiplets listed by Johansson (1978). Forbidden single ionized iron is represented by lines from M.1, 4, 6, 7, 17, 18, 19, 20, 21, 30, 31, 33, 36, 38, 39, 46 and [Fe III] by M.1, 3 and 8.

Of the heavier elements only [Ni II] is present with lines from M.10 and [Zr II] by lines from M.7, 17, 22 and 25. We regard the presence of [Ni II] as dubious.

Table 3. Elements identified in MWC 17 by different authors

Element	Pr. work	C (1974)	L (1977)	SA (1976)	MG (1985b)
H	p	p	p	p	p
He I	p	p	p	p	p
C I	p				
C II	p				
N I	p				
N [I]				p	
N II	p				
N [II]	p	p	p		
O I	p		p		
O [I]	p		p		
O II	p				
O [II]		p			
O [III]	p		p	p	
Na I	p				
Mg II	p				
Al II	p				
Si I	p				
Si II	p		p		
S I	p				
S [I]	p				
S II	p				
S [II]	p		p	p	
Ca I	p				
Ca II	p	p			p
Ti II	p		p		
Ti [II]	p				
V [II]	p				
Cr II	p				
Cr [II]	p				
Fe II	p	p	p		p
Fe [II]	p	p	p	p	p
Fe [III]	p	p	p		p
Ni [II]	p				
Zr [II]	p				

Note: Pr. work stands for present work; C (1974) stands for Ciatti et al. (1974); L (1977) for Leibowitz (1977); SA (1976) for Swings & Andrillat (1976) and MG (1985b) for Martel & Gravina (1985b). p = present.

5. Comparison with previous work

As mentioned in the introduction, the star was analysed by Ciatti et al. (1974), Leibowitz (1977), Andrillat & Swings (1976) and Martel & Gravina (1985b) with low dispersion material. The results are compared in Table 3 and we find that in general the identifications agree with what we have found, except [N I] which we do not observe.

Besides the elements quoted in Table 3, Ciatti et al. (1974) also quote [A III] (λ7135) and Martel & Gravina (1985b) [Ne III] (λ3970) and the CH band at 4300. We do not observe the CH band. The other two lines fall outside the regions observed by us.

6. Spectrum variability

We have already mentioned in the introduction that Gravina (1982) found variations in the different emission features over four nights which can be up to a factor of five. Since her plates were not calibrated, the indications point toward a strong variability. We can quantify this with the lines which are present in our spectra taken at different dates. Table 4 presents the results which are plotted in Figs. 2 and 3. Let us remark that we have only considered lines which on the two plates possess the same identification and which have been measured as isolated features. The fact is that on the two pairs of plates often the lines and their identifications are not the same.

In Fig. 2 one can see clearly that on the average the equivalent widths have changed by a factor of 2, with some individual deviations from the average relation. Figure 3 shows a much more scattered relation, which also holds between the limits of a factor 2. The only exception is the N I line λ8703 which deviates more than that.

The variations found here are in line with what we found in other stars of this type–typically the variations in equivalent width are of the order of a factor 2. Due to

Table 4. Comparison of equivalent widths of lines at different epochs

Line	23.7.93	29.1.98	Identification
8106	2.20	0.78	6.38[Ti II] 39+6.88 [Cr II] 20
8109	1.61	0.93	Fe II J 3
8157	0.97	0.74	Fe II J 6
8210	1.09	0.58	N I 2
8216	3.13	1.77	N I 2
8232	1.04	0.25	O I 34
8304	7.84	4.02	6.11 P 27+ Fe II J at 4.22(2)+4.43(2)
8314	4.71	1.64	P 26
8323	6.12	1.79	P 25
8334	7.70	3.39	P24
8345	10.05	4.95	P23
8351	2.28	4.74	Fe II J 00
8359	15.45	7.30	P22
8367	2.59	1.90	Fe II J 0
8374	11.30	5.01	P21
8392	13.61	7.04	P20
Line	17.8.91	29.1.98	Identification
8413	19.06	8.85	P19
8437	12.80	16.03	P18
8446	261.82	284.02	O I 4
8467	15.20	20.12	P17
8577	1.14	1.32	Fe II J 0
8594	4.85	5.46	N I 8
8596	22.85	28.07	N I 8+P14
8629	4.78	6.52	N I 8
8636	1.09	2.56	Fe II J 7
8655	2.49	2.98	N I 8
8665	28.01	43.29	Ca II+P13
8693	1.05	8.66	S I 6 at 3.98+3.24+4.70
8703	3.07	8.58	N I 1
8711	2.12	5.14	N I 1
8718	1.92	1.43	N I 1
8722	0.82	1.76	[Ti II] 16
8750	26.06	50.64	P12
8766	1.52	3.03	Si I 54
8780	0.98	3.75	Fe II J 2

Note: The first column provides the wavelength of the line in Å; the second and the third, the equivalent width of the line at the dates given at the heading of the table, also in Å. The fourth column provides the line identification.

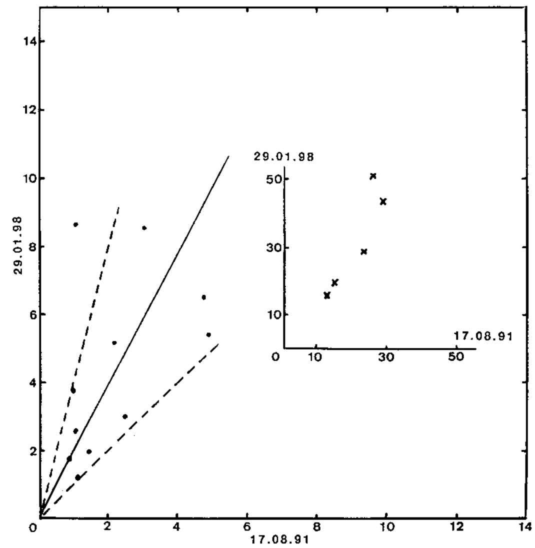

Fig. 2. Equivalent widths of lines in the spectrum from the 29.01.98 plotted against equivalent widths in the spectrum from the 17.08.91. Crosses represent Paschen lines

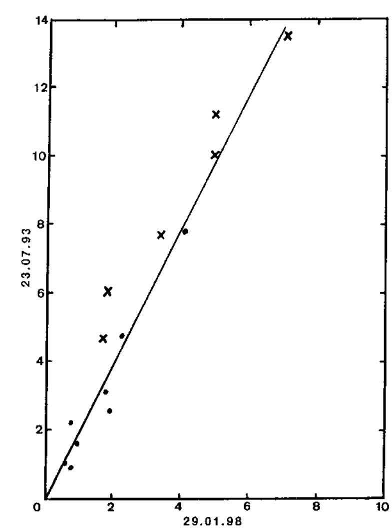

Fig. 3. Equivalent widths of lines in the spectrum from the 23.07.93 plotted against equivalent widths in the spectrum from the 29.01.98. Crosses represent Paschen lines

the lack of time coverage we do not know if these variations are of daily, monthly or yearly character. If we take the example of other stars of this type examined in this series of papers, the variations correspond to time scales of the order of days. In favor of this latter assumption speaks the fact that among the few lines which overlap in the interval 6270 – 6406 on January 28 and 29, 1998 one finds variations of the order of ±20%.

The variations are also evidenced by the Hα measurements carried out by Swings & Andrillat (1981) and the present paper.

7. Spectrum of the underlying star

Since we do not observe absorption lines before 5600 Å, we can only use the few lines in the yellow and the red region. We can identify four lines with Al II(6066), S II(6102), N II(6632) and C II(6800). An early spectral type around B0 is suggested, which would be in line with a shell which has He I in emission. The evidence is not very strong however. Leibowitz (1977) proposed on theoretical grounds a type O9 – O9.5 for the underlying star. The UBV colors measured by Martel & Gravina (1985a): $U - B = -0.20$, $B - V = +0.42$ would lead to a B4 star with $E(B - V) = 0.60$. With such a value of the color excess, an extinction of about 1.8 would be expected, which leads with $M = -1.4$ and $V = 11.6$ to 1700 pc.

Contrary to the opinion of Ciatti et al. (1974) we do not observe the presence of a late type companion.

8. The spectrum of the shell

From the elements we have identified through the emission lines, it is impossible to derive a unique type. Effectively CII, O III, N II and Fe III require a very early type around B0. On the contrary Ca II, Si I, S I correspond to a late A or early F type. As a compromise we may adopt a spectral type of A0 which would correspond to a temperature of 10 000 K. Leibowitz (1977) on theoretical grounds derived a temperature of 8 000 K.

9. Comparison with other stars analysed in this series

Most of the characteristics of this star correspond very well to those of an average B[e] star, except the fact that we observe [Fe III], [N II] and [O III], which have ionization potentials above 25 eV. In this sense MWC 17 is close to HD 51585. We observe however no He II, a fact which differentiates it from planetary nebulae or objects related to them.

Acknowledgements. We thank Mr. J. Marcout from the Strasbourg Observatory for the plots and to Mr. Ph. Moreau from the Haute Provence Observatory for the reproductions of the spectra of Fig. 1.

References

Allen D.A., 1973, MNRAS 161, 145
Allen D.A., Swings J.P., 1976, A&A 47, 293
Altenhoff W.J., Braes L.L.E., Olnon F.M., Wendker H.J., 1976, A&A 46, 11
Andrillat Y., Swings J.P., 1976, ApJ 204, L123
Ciatti F., D'Odorico S., Mammano A., 1974, A&A 34, 181
Gillet D., Burnage R., Kohler D., et al., 1994, A&AS 108, 181
Gravina R., 1982, Inf. Bull. Var. stars 2135, 1
Hamann F., Persson S.E., 1989, ApJS 71, 931
Herbig G.H., 1975, ApJ 196, 129
Herbig G.H., Leka K.D., 1991, ApJ 382, 193
Johansson S., 1978, Phys. Scr. 18, 217
Leibowitz E.M., 1977, A&A 56, 265
Lemaitre G, Kohler D, Lacroix D, Meunier J.P., Vin A., 1990, A&A 225, 545
Martel M.T., Gravina R., 1985a, Inf. Bull. Var. Stars 2750, 1
Martel M.T., Gravina R., 1985b, Inf. Bull. Var. Stars 2724, 1
Meinel A.B., Aveni A.F., Stockton M.W., 1969, "Catalog of emission lines in astrophysical objects", Tucson
Merrill P.W., Burwell C.G., 1933, ApJ 78, 86
Moore Ch., 1959, "A multiplet table of astrophysical interest", NBS Tech. Note, 36
Sistla G., Seung S.H., 1975, A&A 44, 477
Strafella F., Calamai G., Fuensalida J.J., Lorenzetti D., Saraceno P., 1987, Mem. Soc. Astr. Ital. 58, 233
Swings J.P., 1981, A&AS 43, 331
Swings J.P., Andrillat Y., 1981, A&A 103, L3
Thé P.S., de Winter D., Pérez M.R., 1994, A&AS 104, 315
Woodsworth A.W., Hughes V.A., 1977, A&A 58, 105