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Ultraviolet Observations of the Hydrogen-Deficient Variable Star MV Sagittarii†

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Abstract. IUE observations of the hydrogen-deficient irregular variable star MV Sgr obtained in 1980 June-October and also in 1979 November are discussed. These observations show a prominent λ 2200 absorption feature. A value of $E(B — V)$ = 0·55 is deduced from the strength of λ 2200 band assuming that this absorption is caused by interstellar medium. The dereddened continuum obtained at different times can be fitted to a theoretical energy distribution of a helium star model with $T_{\rm eff}$ = 18000 K and log g = 2·5, similar to that of BD + 10° 2179. This theoretical energy distribution, after applying interstellar extinction, gives V = 12·7 mag, agreeing with the observed visual magnitude of ≃ 13 in 1979 November and 1980 June-October. Even though there was no change in the continuum flux, the ultraviolet line-spectrum shows variations. The IUE spectra of 1980 October show enhanced (circumstellar) absorption lines of Fe II, Si II, O I, C I and others along with the absorption lines of a B star. In view of the similarity of the spectroscopic phenomena of MV Sgr with that of α Sco system, a model is proposed in which a cool companion star, surrounded by dust, occasionally blows gas towards the hotter hydrogen-poor B star. This model explains the irregular light variations and the spectroscopic phenomena.

Key words: variable stars—ultraviolet spectra—circumstellar dust

1. Introduction

MV Sagittarii is probably the only known ‘ hot ’ R CrB-type star. The R CrB-type

† Based on observations obtained with IUE satellite at the Villafranca Satellite Tracking Station of the European Space Agency.

stars are hydrogen-poor carbon-rich irregular variables. They seem to be spread out across the HR diagram from early B through F to late R-type stars. A majority of them are later than F. Only two stars—V348 Sgr and MV Sgr—have been classified as hot members of this class with spectral types O–B and B2 respectively. Some of the important questions regarding the evolutionary state of R CrB stars relate to the causes and stage of evolution when the hydrogen-deficiency characteristic occurs and also their future course of evolution in the HR diagram. There seem to be principally two possibilities for the stars to lose the hydrogen envelope: (1) Mass loss from the star in a steady way either as super-winds (Schönberner 1975; Renzini 1981) or explosive ejection of the whole hydrogen rich envelope (Sackmann, Smith and Despain 1974; (2) the hydrogen is consumed by the star itself in the course of its evolution (Paczynski 1971). In such a happening it is very essential to see evidence for extensive mass loss in these stars and further, to estimate the rate of such mass loss. According to Schönberner (1975) R CrB stars are supposed to be progenitors of hot helium-rich carbon stars like BD + 10°2179. Thus MV Sgr, which resembles BD + 10°2179 in the spectrum is a good candidate to look for an evidence for extensive mass loss.

The spectrum of MV Sgr in the blue and red regions has been investigated by Herbig (1964, 1975) when it was slightly below maximum light. At 100 Å mm^{-1} dispersion in the blue, the spectrum of the star resembles very much the carbon-rich BD + 10°2179 (T_{eff} = 18000 K log g = 2·5) with He I and C II absorption lines and very weak or non-existent hydrogen lines. However, in the visual and red region the spectrum is dominated by the emission lines of Fe II, [Fe II], Si II, He I and also H_α. Apparently the emission spectrum is very similar to that seen in v Sgr, which is a known hydrogen-deficient single-lined spectroscopic binary. In addition, the infrared colours obtained by Feast and Glass (1973) and Glass (1978) show that MV Sgr has infrared excesses which can be characterized by a blackbody of about 1500–2000 K, very much unlike the other R CrB stars and also V348 Sgr. It has been suggested by Humphreys and Ney (1974) that the infrared excess in R CrB could be due to the presence of a cool companion. Such a possibility in MV Sgr has already been indicated by Herbig (1975). The radial velocity measurements of Herbig are inconclusive about the variations. Although the presence of emission lines and infrared excess might be the consequence of mass loss, there is no direct observational evidence for such a phenomenon. Thus it is important to investigate the ultraviolet (UV) spectral region, where resonance lines of many elements occur. Moreover, if the irregular light variations are caused by the obscuration by a cloud or shell of circumstellar dust (the traditional explanation for R CrB type of light variations) around the B star, the effects of this extinction would be more pronounced in the UV than in the visible region. With these characteristics in mind, we obtained spectra with the IUE satellite and also used the images of MV Sgr obtained by other observers.

2. Observations and data reduction

All the observations discussed here have been obtained with the IUE satellite (Boggess *et al.* 1978) in the low resolution mode using the large aperture. Table 1 summarises the image number, exposure times, dates of observation and the visual magnitude at

Table 1. Observations.

Image no.	Date	Exposure time m s	$m_v^{‡}$
LWR 4816	1979 June 20	99 59	13·09
LWR 6052*	1979 November 9	99 59	12·85
SWP 7120	1979 November 9	230 00	12·90
LWR 7972†	1980 June 7	32 00	12·97
SWP 10302	1980 October 7	100 00	12·94

*The header and the IUE log shows this as image no. 6053 with the same exposure and observing time.
†λ < 2450 Å underexposed.
‡Calculated from FES counts using the relation given by Holm and Crabb (1979).

the time of these IUE observations. The images LWR 4816, LWR 6052 and SWP 7120 have been obtained from the VILSPA data bank.

The visual magnitude for the images are obtained from the FES counts obtained at the time of observation, with the aid of the relation given by Holm and Crabb (1979). This *V* magnitude is supposed to be accurate to ± 0·1 mag. It should be pointed out that the visual magnitude estimates given in the IUE logs of MV Sgr are not correct for the images discussed here. A few days before the IUE observations of 1979 November (LWR 6052, SWP 7120), the star seems to have gone through a light minimum. Landolt (1979) measured the *UBV* colours of 1979 October 23 as $V = 15{\cdot}18$, $B - V = 0{\cdot}87$ and $U - B = 0{\cdot}17$.

All the data (except LWR 7972) have been processed at Royal Observatory Edinburgh using the standard procedures. These have been briefly described by Nandy and Morgan (1980).

To improve the photometric accuracy of the absolute fluxes, fluxes averaged over 50 Å band have been computed. These broad-band fluxes with estimated errors are given in Table 2. The image LWR 7972 was underexposed below λ 2450 and was not used, but the fluxes agree with those obtained from the other two images.

3. *λ* 2200 feature, reddening and distance

The fluxes given in Table 2 show that they agree with each other within the standard deviation. These fluxes are plotted in Fig. 1, along with an ANS observation. MV Sgr was observed on 1975 April 1 by ANS. The observation with higher count-rate is shown in the figure. These observations show the prominent broad depression at 2200 Å, that is characteristic of the interstellar extinction curves. Assuming that this band is of interstellar origin, the reddening is estimated as follows.

Because of the crowding of the lines in the spectrum, only the high points of the 50 Å band fluxes are considered for the representative energy distribution to be corrected for interstellar reddening. This correction is accomplished by assuming that the mean reddening curve obtained by Seaton (1979) is applicable. This curve was tried with different values of $E(B — V)$ to get a smooth stellar energy distribution. A value of 0·55 mag is derived for $E(B — V)$ with an uncertainty of ± 0·05 mag.

Herbig (1964) had previously estimated the reddening of MV Sgr as $E(B — V) = 0{\cdot}44$ by assuming that the intrinsic *UBV* colours of BD + 10°2179 and MV Sgr

Table 2. Observed flux with 50Å bandpass and its standard deviation, in units of 10^{-14} erg cm^{-2} s^{-1} Å^{-1}.

	SWP 7120		SWP 10302			LWR 6052		LWR 4816	
λ	F_λ	σ	F_λ	σ	λ	F_λ	σ	F_λ	σ
1275·68	1·56	0·23	1·13	0·44	2029·20	1·30	0.29	1·33	0·27
1326·22	1·67	0·29	1·53	0·56	2080·72	1·26	0·20	1·16	0·22
1376·22	2·54	0·32	2·73	0·44	2132·24	1·02	0·28	0·94	0·24
1427·30	2·57	0·45	2·58	0·47	2183·76	1·19	0·76	0·98	0·70
1477·84	3·10	0·36	3·01	0·39	2235·28	0·81	0·36	0·94	0·32
1528·38	2·94	0·41	3·07	0·51	2286·80	0·91	0·21	1·12	0·34
1578·92	2·88	0·50	2·84	0·49	2338·32	1·50	0·27	1·43	0·28
1629·46	3·13	0·36	2·98	0·43	2389·84	1·56	0·27	1·60	0·17
1680·00	3·44	0·31	3·59	0·41	2441·36	2·12	0·29	2·17	0·32
1730·54	3·00	0·30	3·12	0·48	2492·88	2·37	0·30	2·26	0·21
1781·08	2·79	0·61	2·74	0·62	2544·40	2·40	0·19	2·43	0·20
1831·62	2·82	0·23	3·01	0·30	2595·92	2·27	0·37	2·33	0·29
1882·16	2·20	0·24	2·22	0·29	2647·44	2·73	0·27	2·81	0·20
					2698·96	3·02	0·25	3·10	0·19
					2750·48	3·39	0·19	3·43	0·22
					2802·00	3·48	0·48	3·45	0·45
					2853·52	3·88	0·36	3·85	0·38
					2905·04	3·93	0·37	3·85	0·30
					2956·56	3·91	0·21	3·90	0·15
					3008·07	3·76	0·42	3·77	0·39
					3059·59	3·38	0·28	3·19	0·30
					3111·11	3·69	0·37	3·53	0·26
					3162·63	4·03	0·54	4·11	0·61

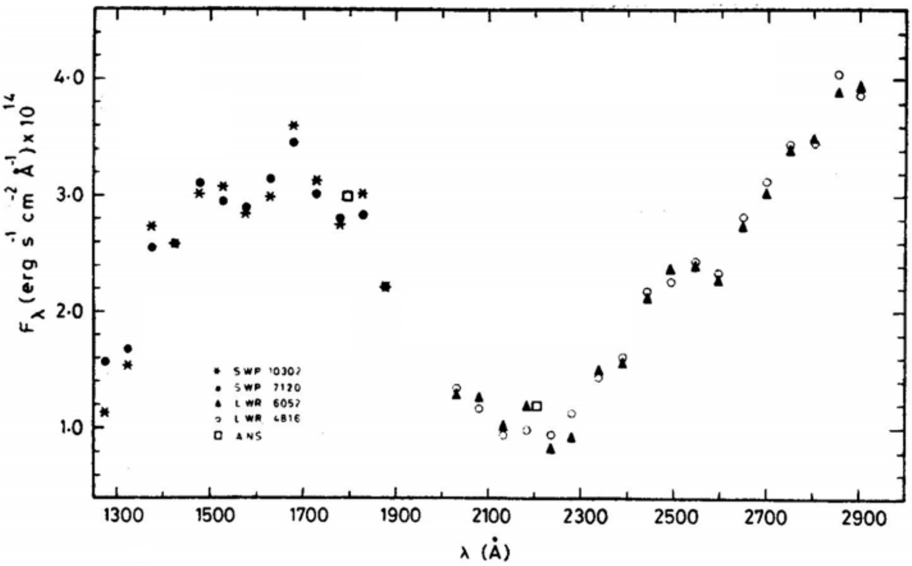

Figure 1. Observed energy distribution in the UV with 50 Å passband.

are the same. He used the *UBV* colours obtained by Paczynski, when the star was at $V = 12{\cdot}70$.

The assumption that the reddening is entirely due to the interstellar medium seems to be justified for the following reason. The distribution of $E(B — V)$ in the galactic plane is given by FitzGerald (1968) and Lucke (1976). For distances greater than 1·5 kpc in the region 2° north of the position of MV Sgr (l = 13°.4, b = — 7°.9), the mean $E(B — V)$ is between 0·6 and 0·9 (Fig. 7 of FitzGerald 1968). A minimum distance of 1·5 kpc thus leads to an absolute magnitude M_V of 0·06, which agrees with the estimated lower limit of MV Sgr (Herbig 1964). From the data obtained with the sky survey telescope (S2/68) in the TD-1 satellite, Nandy *et al.* (1978) mapped the strength of the 2200 Å feature and mean $E(B — V)$ as a function of distance in the galactic plane for all galactic longitudes. In the longitude zone of MV Sgr, the mean $E(B — V)$ per kpc is $\simeq$ 0·22, which gives a distance of 2·5 kpc for MV Sgr, if the estimated $E(B — V)$ is entirely due to the interstellar medium. This distance, in turn, leads to an absolute magnitude M_V of — 1·05. This is in the range of M_V (— 1 to —2) preferred by Herbig (1964) for MV Sgr on the grounds that M should be same for MV Sgr as for the rest of R CrB stars. The above estimate of — 1·05 for MV Sgr is also close to the estimated M_V = 1·6 of BD + 10°2179 (Klemola 1961). Although there is some uncertainty in the estimated M_V of MV Sgr as discussed by Herbig (1964), the above estimates indicate that the reddening as determined from 2200 Å band is all due to the interstellar medium.

4. UV continuum

The reddening-corrected energy distribution of MV Sgr is compared with the energy distributions computed by Heber and Schönberner (1980), with abundances of

Table 3. Published *UBV* photometry of MV Sgr.

Date	V	$B-V$	$U-B$	Observer
1963 July 26, August 10	12·70	0·26	−0·60	Paczynski (Herbig 1964)
1979 October 23	15·18	0·87	0·17	Landolt (1979)

n_H = 0·0, n_{He} = 0.99 and n_C = 0·01 for different temperatures. As can be seen from Fig. 2, UV energy distribution of MV Sgr fits well with the theoretical energy distribution for a model of T_{eff} = 18000 K and log g = 2·5—same as that which fits BD + 10°2179—showing further similarities between these two stars. The uncertainty in fitting model energy distribution, with respect to changes of carbon abundance in particular, is not known. The visual magnitude obtained from the computed model energy distribution is V_0 — 10·96 and after applying the interstellar extinction of 1·76 mag, the visual magnitude is 12·72. The estimate of the visual magnitude at the time of 1979 and 1980 IUE observations (Table 1: $m_v \simeq$ 13·0) is slightly fainter or agrees with the above estimate.

Fig. 3 shows all the published *UBV* (Herbig 1964; Landolt 1979), infrared (Glass 1978) and IUE observations—all corrected for interstellar extinction—plotted along with the theoretical energy distribution (T_{eff} = 18000 K, log g = 2·5) of the helium star. The value of total-to-selective extinction ratio R is taken to be 3·2. The energy distribution longward of 0·55 μm (V band) is an extrapolation of the black body (T = 18000 K) line. The *UBV* observations of Paczynski (Herbig 1964) follow the theoretical energy distribution of the helium star. Landolt's *UBV* observations

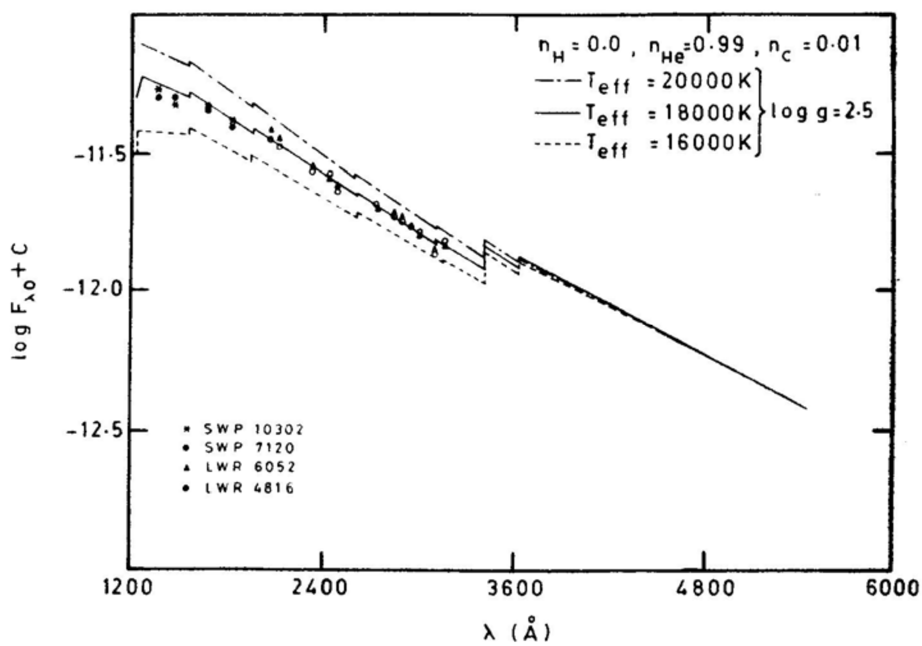

Figure 2. Reddening-corrected energy distribution of MV Sgr superposed on the theoretical energy distributions computed by Heber and Schönberner (1980). The ordinate is log F_λ + ·396.

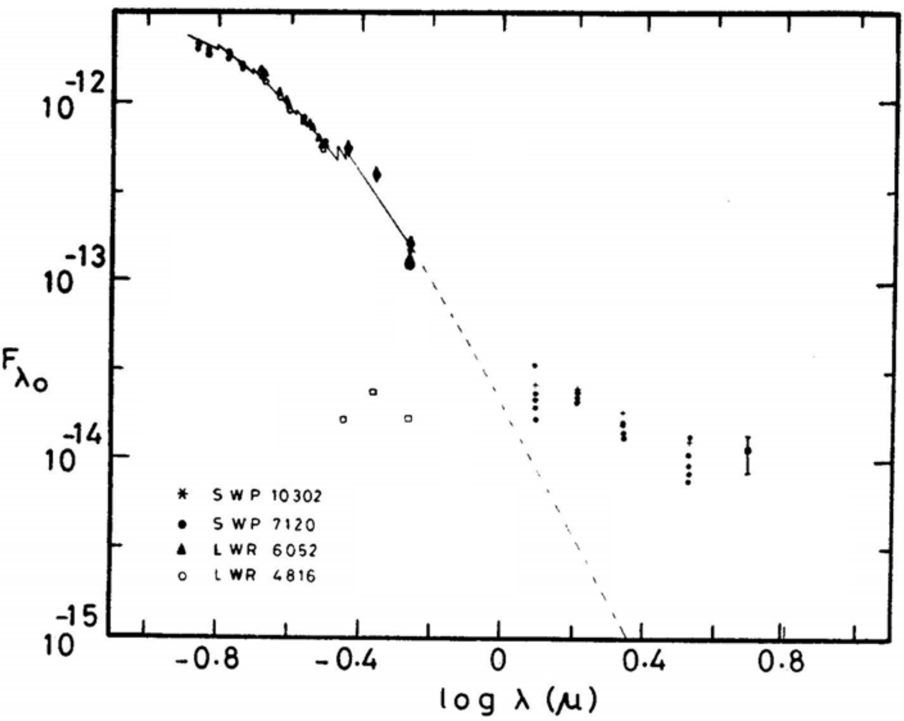

Figure 3. Reddening corrected fluxes of all the UV, *UBV* and infrared observations discussed in this paper plotted with the theoretical energy distribution of Heber and Schönberner for T_{eff} = 18000 K black body longward of 0·55 μm. (*V* filter).

♦ *UBV* observations of Paczynski (1971).

□ *UBV* observations of Landolt (1979).

× *V* magnitude estimated from FES counts for SWP 10302 and LWR 7972.

⊙ *V* magnitude estimated from FES counts for SWP 7120 and LWR 6052.

●, + Infrared observations of Glass (1978).

were obtained when the star was quite faint, and show that the colours become redder.

5. Line spectrum

The observed low-resolution short-wavelength spectra SWP 7120 (dashed line) and SWP 10302 (full line) obtained in 1979 and 1980 are shown in Fig. 4. The line spectrum shows many absorption lines and there does not seem to be any prominent emission line in both the spectra (although there are a few spikes which might not be spurious). Moreover because of high interstellar extinction the spectrum is expected to show many interstellar lines. The line spectrum in absorption is characterized by two types of features: (1) those that do not change in strength between the two spectra (SWP 7120, SWP 10302) within about 5–10 per cent and (2) the lines which change their strength and are particularly enhanced in SWP 10302.

The line identification has been done with the help of the line list for BD + 10°2179

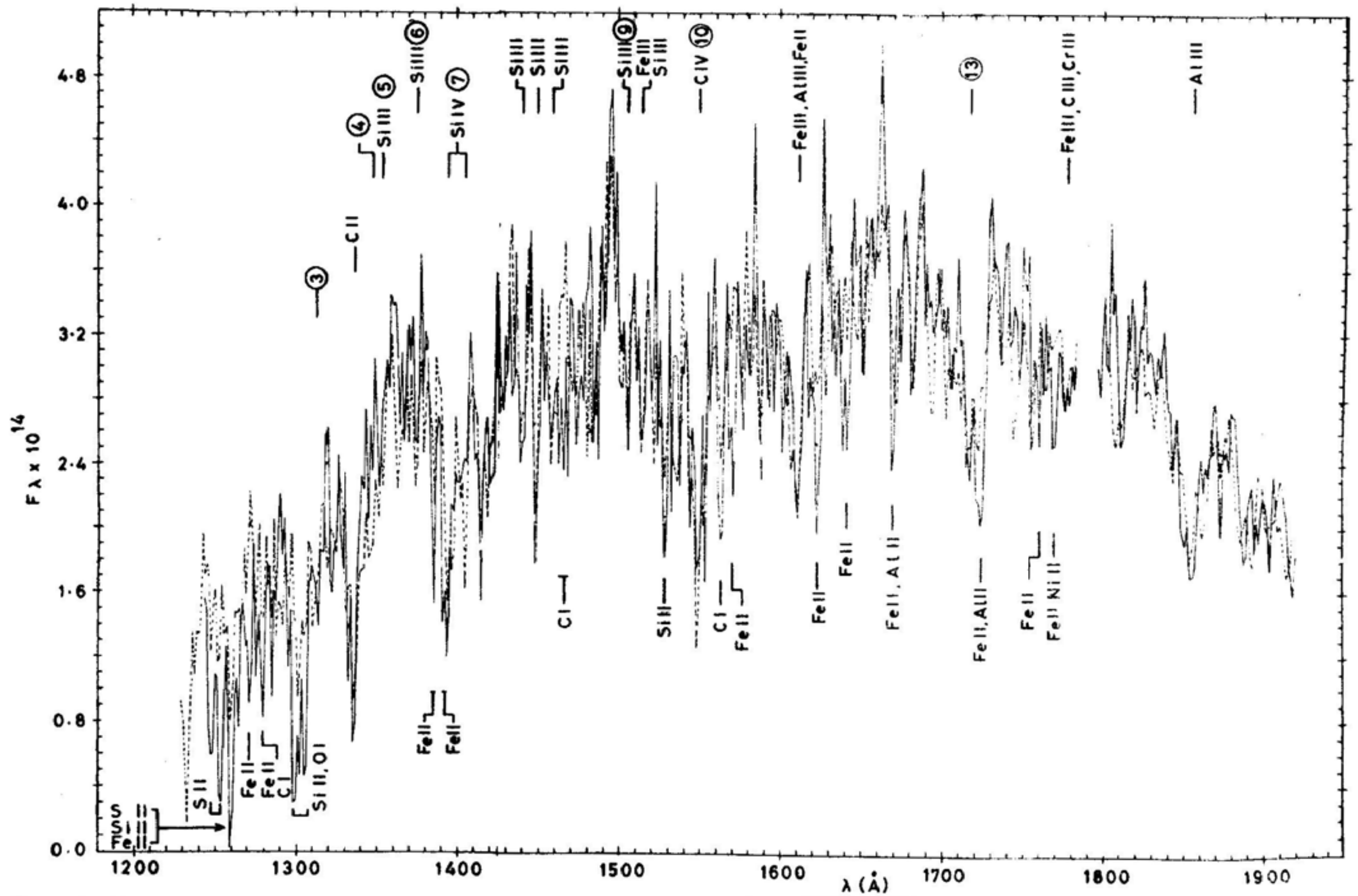

Figure 4. Low-resolution IUE spectra of MV Sgr at two different occasions: SWP 10302 (continuous line) obtained in 1980 October when the star was at $m_v \simeq 11{\cdot}4$ and SWP 7120 (dashed line) obtained in 1979 November when the star was at $m_v \simeq 13$. The gap near $\lambda\lambda$1780–1790 is the place where the reseaux mark occurs (not plotted).

(Schönberner and Hunger 1978) and line identification lists of B stars by Stalio and Selvelli (1975), Kelly and Palumbo (1973), Moore (1950) and Johansson (1978).

Many of the lines which do not change in strength are those that are seen (and expected) in a star of spectral type ~ B2. Some of these identifications are shown on the top of Fig. 4. The identification of the numbered lines is given by Nandy and Morgan (1980). There might be some enhancement in some of these lines in the spectrum of SWP 7120. The other variety of features which are strong in SWP 10302 and are either weak or absent in SWP 7120 are mostly due to Fe II, C I, Si II, Al II, O I and perhaps S I. These lines are not expected to be strong in a B2 star. Some of these are shown below the spectrum in Fig. 4. Particularly, the region between 1560–1720 Å shows the presence of strong Fe II lines in absorption in SWP 10302 relative to SWP 7120. A list of some of these lines are given in Table 4. This trend also seems to be true with Fe II lines in the long wavelength range (*e.g.* multiplets 62 and 63). These lines are denoted as circumstellar shell lines for further discussion.

As mentioned in the introduction, Herbig (1975) had identified several lines in emission, mainly due to Fe II, [Fe II], Si II *etc.* It is of interest to see whether any Fe II line emission occurred in the UV, when the star was slightly fainter ($m_v \simeq 13{\cdot}0$: same visual magnitude as in SWP 7120). It is hard to detect incipient emission in the absorption lines on this low-resolution spectra, but none of the Fe II emissions rise above the level of the continuum in SWP 7120. The upper levels of the Fe II emissions seen in the red are connected to the strong UV lines; particularly multiplet numbers 34, 38, 40, 73 and 74 are connected to UV 1, UV 62, UV 63 *etc.* Even these multiplets do not seem to get strengthened in absorption in LWR 6052 ($m_v \simeq 13$) compared with LWR 7972 and 4816. Moreover, they seem to be weak. This probably indicates that resonance fluorescence might not be a dominant process for the excitation of the Fe II emissions seen in the blue and red regions of the spectrum.

The Si II lines λλ 6347, 6371 have also been seen in emission by Herbig. The lower levels of these transitions are the upper levels for the resonance lines λλ 1533, 1526. Although there is some weakening at λ 1526 in SWP 7120, it is not clear whether it is because of the emission. Moreover, this line might have been blended with an interstellar component.

Changes in the emission-line strengths also seem to occur in the blue region of the spectrum. Westin (1980) has published a tracing of the spectrum of MV Sgr in the wavelength range λλ 3700–4200 and 4380–4925. The visual brightness of the star at the time of this observation is not known but it could be around maximum light. The only discernable emission line in this spectrum is λ 4584 of Fe II. This is in contrast to the description of the 1963 blue spectrograms by Herbig (1975) where he could certainly see emission at λλ 4549, 4555, 4583, 4731 and possibly at λλ 4258, 4314, 4385.

The line spectrum of BD + 10°2179 in the IUE wavelength range has been analysed by Schönberner and Hunger (1978) and Heber and Schönberner (1980). The strongest feature in the whole UV spectrum is that of the C II resonance lines λλ 1334–35. They use these lines to calculate the carbon abundance for the reason that it falls on the damping part of curve of growth and hence is independent of microturbulence. In MV Sgr which is very similar to BD + 10°2179, the λλ 1334–35 feature is not as strong, even though it might have a blended interstellar component (The central depth ≃ 0·7 in MV Sgr whereas it is 0·99 in BD + 10°2179). Herbig (1964) has already commented about the weakness of C II lines in MV Sgr

Table 4. Identifications for some enhanced (circumstellar) lines in SWP 10302.

λ_{obs}(Å)	λ(Å)	Identification (multiplet no.)
1247	1246·7	Si II (8)
	48·4	
1252	1250·5	S II (1)
	53·8	
	1251·2	Si II (8)
1260	1260·5	Fe II (9)
	59·5	S II (1)
	60·7	Si II (4)
1272	1271·2	Fe II (9)
	72·0	
	72·6	
1275–77	1275·1	Fe II (9)
	75·8	
	1277·1	C I (7)
	77·3	
	77·6	
	77·8	
1298–1304	1302·1	O I (2)
	04·8	
	06·0	
	1304·4	Si II (3)
	1298·9	Si III (4)
1385	1385·5	Fe II
	85·0	S I (7)?
1465-68	1463·3	C I (37)
	1467·4	C I (36)
	67·8	
	68·4	
1526	1526·7	Si II (2)
	1525	Fe III
1562	1561·3	C I (3)
	61·4	
	1562·4	Si II (11)
	62·8	
	1563·7	Fe II (45)
1567-70	1570·2	Fe II (45)
	74·9	
	1566·8	Fe II (44)
	1569·6	Fe II (44)
	74·9	
1622	1621·3	Fe II (8)
	25·9	
	1625·5	Fe II (43)
1631-41		Fe II (8)
		Fe II (43)
		Fe II (42)
		Fe II (68)
		V II (18)?
1670	1670·7	Al II (2)
	1670·7	Fe II (40)
1722-25	1719·4	Al II (6)
	21·2	
	25·0	
	1720·0	Fe II (64)
	20·6	Fe II (38)
	26·3	
	24·8	Fe II (39)
	25·0	Fe II (37)
1760	1761·3	Fe II (100)
	60·4	Fe II (101)
	1761·9	Al II (5)
	60·1	
1771	1772·5	Fe II (99)
	1773·9	Ni II (3)?

in the blue region. Thus carbon might not be as abundant in MV Sgr as it is in BD + 10°2179.

We also note that no blueshifted components of the P Cygni type have been seen in the UV spectrum of MV Sgr.

6. Discussion

The main aspects to be considered for an explanation in terms of a model for MV Sgr are the following:

The spectrum in the blue shows absorption lines mainly due to a hydrogen-poor helium star of approximate spectral type B2.

The UV continuum can be well matched by a helium star model of $T_{\rm eff}$ = 18000 K, log g = 2·5 consistent with the approximate spectral type of B2. Even the UV absorption-line spectrum, when the star is $m_v \simeq 13$ (SWP 7120) is consistent with this spectral type.

The optical emission line spectrum seen at $m_v \simeq 13$ is mainly due to Fe II, Si II, [Fe II], H_α, He I, O I, N I, and Ca II. No emission lines are clearly detectable in the UV.

Even at maximum light, on certain occasions (SWP 10302) there appeared circumstellar shell (absorption) lines due to Fe II, C I, O I, Si II, Al II *etc.* Those of Fe II were however, the strongest.

Infrared excess in *JHKL* bands can be characterized by a blackbody temperature of 1500–2000 K (Glass 1978). Infrared photometric variations occur with a range in magnitudes of $\Delta J = 0.76$, $\Delta H = 0.36$, $\Delta K = 0.33$, $\Delta L = 0.63$, $\Delta(K - L) = 0.56$.

Finally, irregular light variation in the range 11·71–15·6 m_{pg} has been reported by Hoffleit (1959).

The colours $B - V$ and $U - B$ are redder at the light minimum as seen when the star was at V = 15·15 (Landolt 1979).

The traditional picture of an R CrB star is that the light minima are supposed to be caused by a cloud (or shell) of dust grains (formed presumably from the ejected gas) obscuring the star light. In such a case, the presence of circumstellar shell lines in 1980 IUE spectra without any accompanying changes in the visual light is puzzling, particularly since, these shell lines were absent or very weak just after the light minimum in 1979. This situation is in contrast to the case with R CrB or RY Sgr, where the shell lines in the optical region (*e.g.* Ca II H and K, He I λ 3889, Na I D) are seen during the late recovery phase of the light curve (Gaposchkin 1963; Rao 1974; Alexander *et al.* 1972). Unless there is another ejection of gas in the line of sight in 1980 and this ejection is not accompanied by the formation of dust which causes visual extinction, the explanation for the presence of cooler circumstellar lines becomes difficult in a single star model for MV Sgr. On the other hand, as mentioned in the introduction, in the binary star model with a cool companion the circumstellar shell lines find a natural explanation in the gas ejected from the cooler star towards the hotter B star.

MV Sgr also shows infrared excess in *JHKL* wavelength bands which can be fitted to a blackbody temperature of 1500–2000 K (which also varies). Any stellar object of temperature 2000 K or slightly hotter would be able to satisfy the above condition. But the luminosity should be $L/L_\odot > 10^3$. It is hard to specify the nature of the companion with the uncertainty in the M_v for the B star and in the estimation of $T_{\rm eff}$ for the cool star. But normally such a star would be easily recognisable in the spectrum and also from infrared photometry. The spectra obtained by Herbig (1975) in the red do not show the presence of any such companion. The spectrum is smooth with many emission lines and few absorptions. One of the possibilities to overcome the above difficulty is that this late-type companion itself is covered up with circumstellar dust which absorbs the visible and near infrared flux and re-radiates it in the far infrared wavelengths beyond 3·5 μm (L band). Some support to this possibility comes from the 5 μm observation by Glass (1978) which shows more flux than could be fitted by a blackbody at 1500–2000 K, to which the J, H, K and to some extent L fluxes can be fitted to. Thus the model might be like that of the α Sco system with a B2 star (hydrogen-poor in case of MV Sgr) and a late-type giant (a supergiant in the case of α Sco). There seem to be several similarities between the two systems.

The emission spectrum of MV Sgr described by Herbig is very similar to that of the emission nebula around α Sco B described by Swings and Preston (1978) except that the red star dominates in the long wavelength range so that emissions are seen in the blue. In the case of MV Sgr the B star dominates the blue region and hence the emission lines are seen in the red. Both systems show emission lines of Fe II, [Fe II], Si II, H_α (no other hydrogen line in emission), He I (λλ 6678, 5876, 7065, in the case of MV Sgr and probably λ 4471 in *α* Sco). However, in *α* Sco the [Fe II] lines are stronger whereas in MV Sgr the Fe II lines are stronger. This may indicate a higher electron density in the gas around MV Sgr. The similarities between these two systems also extend to the circumstellar (shell) absorption lines seen in the B star spectrum, *α* Sco B shows shell lines of Fe II, Mn II, Cr II, Zn II and also Ti II *etc.* in the spectrum studied longward of λ 2000 (van der Hucht, Bernat and Kondo 1980). MV Sgr at maximum light shows lines of Fe II, C I, O I, Si II, Al II and others in the wavelength range λλ 1240–1900 (SWP 10302). The degree of ionization in the circumstellar gas also seems to be roughly the same in both the stars.

With this analogy of *α* Sco system the following scenario is suggested for MV Sgr. The system is a binary with a B2, hydrogen-poor, helium star and a cool companion. The companion is normally covered by its own circumstellar dust and might also be a variable as seen from the variations in infrared flux. On certain occasions, enhanced cool stellar wind is blown towards the B star giving rise to the circumstellar shell lines due to Fe II, C I, O I *etc.* without diminishing the continuum of the B star. There is also the possibility that there might be a steady wind all the time. However, when some dust is also blown towards the B2 star, a deeper visual minimum occurs and the colours of the B star get redder as observed by Landolt (1979) when the star was at V = 15·18; presumably such blow-up of gas and dust occurs irregularly since the visual minima are irregular. The emission lines of Fe II *etc.* observed by Herbig could come from a nebula around the B star fed from the stellar wind of the cool star. Good radial velocity measurements of the emission lines would be helpful regarding this point.

It is of interest to see how the extinction properties of the circumstellar dust around the hot star like MV Sgr differ relative to other R CrB stars if the visual minima of MV Sgr are caused by the dust. The *UBV* colors observed by Paczynski and Landolt at maximum and minimum (Table 3) give the following reddening relations

$\Delta V/\Delta(B-V) = 4{\cdot}1$ and $\Delta(U-B)/\Delta(B-V) = 1{\cdot}26$ for the ratio of total-to-selective absorption and for the two-colour relation respectively. These values are similar to the reddening relations observed for RY Sgr (*i.e.* 4·3 and 1·3, Alexander *et al.* 1972) and SU Tau (4·3 and 1·47, Rao 1980) during the recovery phase of the light curve.

Obviously more observations in the UV, visible and infrared regions are needed to study the system more exhaustively.

7. Conclusion

The UV and visual continuum of MV Sgr can be fitted to the theoretical energy distribution of a hydrogen-deficient carbon-rich helium star of $T_{\rm eff}$ = 18000 K and log g = 2·5, after correcting for interstellar reddening of $E\ (B - V) = 0{\cdot}55$. The IR excess and the spectroscopic phenomenon of the transient shell absorption lines could be caused by a cool companion blowing gas and dust towards the hot star in a system similar to the α Sco system. Thus if the binary model is correct, MV Sgr might have had a different scheme of evolution for the loss of its hydrogen (envelope) than other single stars like R CrB.

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