PHOTOMETRIC PROPERTIES OF THE EXTREME HELIUM STARS

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The purpose of this paper is to review the photometric histories of the extreme helium stars.

I. A PHOTOMETRIC OVERVIEW

There exists a small number of hot blue stars whose spectra contain strong helium spectral lines but no, or only very weak hydrogen lines. These stars have had a series of descriptive names, first helium stars, and more recently extreme helium or hydrogen-deficient stars. These names tend to be used interchangeably. Popper (1942) identified the first member of this group, HD 124448. Bidelman (1952) found the second such star, HD 160641, and Thackeray and Wesselink (1952) nearly simultaneously discovered the third, HD 168476 (see Hill, 1969a).

There have been three general reviews of the properties of the helium or hydrogen-deficient stars; in chronological order, the reviews have been by Hack (1967), Dinger (1970), and Hunger (1975).

A tabulation of the original eight extreme helium stars, plus two close binary systems which have quite similar spectra, is given by Hunger (1975). An additional seven extreme helium stars are described by Drilling (1980). Finally, Drilling (1985) recently has discovered three more such objects, thereby more than doubling the number known, and bringing the total number of extreme helium stars to twenty-one. He has found the new members of the class during spectroscopic studies of stars classified as OB+ in the catalogue of Stephenson and Sanduleak (1971).

An object closely related to the extreme helium stars is BD+13°3224 = V652 Her. The words 'closely related' are used because some investigators describe the star as extreme helium and others do not. Even the same individual(s) is not always consistent. Landolt

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(1975) found BD+13°3224 to be variable in light with a period of $0^{d}.107995$. Since then, a series of papers discussing its characteristics have appeared in the literature, mostly in the Monthly Notices of the Royal Astronomical Society.

Photometric studies of the extreme helium stars go back some twenty years. Both Herbig (1964, 1967) and Hill (1965, 1967a) pointed out the importance of investigating whether or not the helium stars were variable in light. Variability potentially tells one something about the star's structure and evolution. These comments resulted in great part from the light variability of the apparently related star, MV Sgr (Hoffleit 1959, Herbig 1964). Hill (1967b) noted that, other than MV Sgr, no other helium star was known to be variable in light.

Landolt (1968) initiated an observational program which was occasionally to check the then known helium stars for brightness changes. Intensive observations over a period of a few nights on two or three occasions per year would then reveal both short-term and long-term brightness changes, if they occurred. Possible small changes were noted. Hill (1969b) reported on photoelectric observations of HD 124448, HD 160641, and HD 168476. He noted that while HD 124448 appeared to be constant, both HD 160641 and HD 168476 showed 'micro-variation' in magnitude but not in color. In a review lecture, Hill (1969a) said that no helium stars other than MV Sgr were known to vary in brightness by a 'significant' amount; this statement has withstood the test of time. He further noted that all of the original groups of helium stars had high radial velocities. The smallness of their proper motions and the strength of the interstellar lines in their spectra suggested that the helium stars were distant and hence rather luminous objects.

Landolt (1973a) reported that a series of UBV photoelectric observations obtained during the years 1968-72 showed that although some brightness variations had occurred, none were large. The data indicated a decade-long secular brightening of HD 168476 when compared to Hill's data. And, a seven hour monitoring of HD 160641 indicated a definite trend in the sense that the star brightened by $\sim 0^{m}.1$ over a seven hour period. Already the diversity in the photometric behavior of the extreme helium stars was becoming evident: those nearly and/or constant, those with variations under a day, some of unknown duration, and two, if one includes MV Sgr, with light variations which change on a time scale of years.

One year later, Landolt (1974, 1975) confirmed the variability of HD 160641 and discovered the periodicity of BD+13°3224 (V652 Her). A period near $0^{d}.6$ seemed most probable for the former star. BD+13°3224 was found to have a period of 0.107995 days. Not since has an extreme helium star been found to have as simple a light variation as that possessed by BD+13°3224. Investigations of this star continue (Kilkenny 1985).

Stromgren four-color (uvby) photometry was made of hydrogen-deficient stars by Walker and Kilkenny (1980). They found nothing peculiar in these stars' locations in the color-color index diagrams. They did find the hydrogen-deficient stars to have higher c_1 indices than expected for their temperatures. This is so because there is no Balmer discontinuity since there is no hydrogen present. Walker and Kilkenny found that Stromgren photometry indicated the extreme helium stars to be cooler than B stars of the same [u-b] color index. These four-color data further confirm the light variability of HD 160641 and HD 168476. Although Hill (1969b) thought that HD 124448 was constant, Landolt (1973a) and Walker and Kilkenny's data indicated a probable low-amplitude variation.

Both the broad-band photometry (Landolt 1979a) and the intermediate band photometry (Walker and Kilkenny 1980) pointed toward the surmise that to some extent all of the extreme helium stars are variable in light. Most of the variations are complex in nature and will entail strenuous observational and theoretical efforts before our understanding is complete.

Drilling, Landolt, and Schönberner (1984) published broad band UBVRIJHKL photometry of most known extreme helium stars and hydrogen-deficient binaries. Only the latter show an infrared excess. The remaining stars apparently are single objects; none of them shows an infrared excess. The conclusion is that the hydrogen-deficient binaries are encased in dust shells, whereas the extreme helium stars are not.

The observed colors of the extreme helium stars have been used to derive their reddenings and effective temperatures. An initial work by Heber and Schönberner (1981) has been followed by Schönberner et al. (1982) wherein the λ 2200 Å feature in the ultraviolet IUE spectra was used as a criterion in establishing the color excess.

II. THE INDIVIDUAL STARS

The following material is a summary of the photometric histories of the stars now accepted as extreme helium stars. Currently available broadband UBVRI photoelectric data are summarized in Table I. Except for HD 30353 (KS Per), BD+37°1977, LSS 3184, and υ Sgr, all the photometric data are from the author's observations over the past seventeen years. All these data have been tied into the Johnson UBV and the Kron-Cousins UBVRI photometric systems as defined by Landolt (1973b, 1983). A few of the author's earliest extreme helium star UBV photometric measures were tied into Johnson's (1963) standard stars. The only extensive four-color (uvby) photometric data of which the author is aware is that of Walker and Kilkenny (1980), mentioned above. Johnson system JHKL photometry, tied into Elias et al. (1982) standard stars, for more than one-half of these objects has been reported in Drilling, Landolt, and Schönberner (1984). The only two stars which show a pronounced infrared excess are υ Sgr and LSS 4300, each a hydrogen-deficient binary. The conclusion was drawn that some hydrogen-deficient binaries have circumstellar dust shells; however, the single extreme helium stars do not.

Heber and Schönberner (1981) made the first attempt to systematically derive the color excesses of the extreme helium stars. They used a grid of unblanketed model atmospheres together with observations in the literature to derive the stars' color excess and effective temperature. The following year, Schönberner et al. (1982) improved the color excess and effective temperature determinations through use of line-blanketed model atmospheres and identification of the usefulness of the 2200 Å feature in the ultraviolet spectral region as the criterion for zero reddening. The color excesses so determined are listed in Table I. One notes that many of the extreme helium stars are heavily reddened as might have been expected from the strength of the interstellar lines in their spectra and their low galactic latitude.

II.1. BD+37°442

Rebeirot (1966) found that the star BD+37°442 belonged to the helium star group. She found the star to have a radial velocity of -156 km/sec, and estimated the star's luminosity to be perhaps as great as $M_v = -2$.

Darius et al. (1979) found an effective temperature of about 55000 °K. Rossi et al. (1980) discovered P Cyg lines of N V and C IV in IUE high resolution spectra. These observations provided evidence for the presence of mass outflow. Their absorption components extend up to -2200 km/sec. No λ 2200 Å band was detected; hence the color excess E_{B-V} was estimated to be zero.

Landolt (1968, 1973a) published UBV photometry of BD+37°442 extending over 1967-70; in addition, he has unpublished data for the years 1974-77. Although there are maximum differences of $0^m.05$ or so in these data, no obvious periodicity exists. He finds average magnitudes and colors of V = 10.01, B-V = -0.28, and (U-B) = -1.16.

Bartolini et al. (1982) believe that the star that Rebeirot (1966) discovered was BD+37°443, and not +37°442. A recent check by this author at the telescope, though, showed the original identification to be correct. Bartolini et al. (1982) also believed that they found both short period light variations (on the order of 10-15 min.) and longer time scale variations (on the order of months). Their data are not extensive.

Landolt's several hundred unpublished UBV differential photometric observations show no obvious light variations.

II.2. HD 30353 = BD+43°1069 = KS Per

KS Per is a hot hydrogen-deficient star. It is a spectroscopic binary with a period of 360 days. Studies on the UBV photometric system have been reported by Osawa et al. (1963). They find a roughly sinusoidal light curve of amplitude $0^m.14$ and period 30-40 days. The UBV magnitude and colors in Table I are straight averages of data taken from Hiltner (1956), Nariai (1963), and Landolt (1968) in order that the reader have a feel for the star's photometric characteristics. Since it is a binary and will be discussed elsewhere in this colloquium, no further comments will be made.

II.3. LSS 99

The star LSS 99 was recognized as an extreme helium star by Drilling (1985). Landolt obtained UBVRI photometry for LSS 99; these new data are given in Table I. Its colors predict that it is heavily reddened. Too few data are available to say anything about potential variability.

II.4. BD+37°1977

The BD star +37°1977 was recognized as a hydrogen-deficient star by Berger et al. (1974). Wolff et al. (1974) found the star to be a very hot subdwarf, with a temperature of 50,000 °K. The hydrogen lines were weak or absent; the radial velocity was -59 km/sec. Darius et al. (1979) found T_e = 55,000 °K from high resolution IUE spectra. Rossi et al. (1980) reported that P Cygni lines of N V and C IV gave evidence for mass outflow from the star. Absorption components extend up to -2200 km/sec. Since no λ 2200 Å band was detected, they concluded that $E_{B-V} \sim 0.0$. The only photometry known to this author was quoted by Rossi et al. (1980): Johnson V = 10.21, and Stromgren (b-y) = -0.123.

II.5. BD+10°2179

Klemola (1961) found that BD+10°2179 belonged to the small group of objects then known as helium stars. His photometric observations indicated that V = 9.95, (B-V) = -0.18, and (U-B) = -0.90. He determined the star's radial velocity to be +155 km/sec. The proper motion components of $\mu_\alpha = -0''.0285$ and $\mu_\delta = +0''.001$ per year quoted by Klemola were determined by Kopff, Nowacki, and Gondolatsch (1932). Landolt (1968, 1973a, and unpublished) suspected variability at optical wavelengths. Bartolini et al. (1982) confirmed the variability of BD+10°2179. They found an amplitude of 0.08 in V, and were able to phase the data with a period of 0.162645 days. The data of Bartolini et al. (1982) consisted of 38 measures obtained on 7 nights during a 529 day time interval. Subsequent observational programs by Hill, Lynas-Gray, and Kilkenny (1984) and by Grauer, Drilling, and Schönberner (1984) failed to find any light variation. The former had an unstated number of observations taken on 16 nights in the time frame 1979-1982; these data showed no detectable variations above the 0.02 magnitude level. The latter data consisting of nearly 3000 individual five second integrations covered a time interval of 0.21 days on 10 April 1983 U.T. and showed no light variations greater than 0.002 magnitude. Grauer et al. used a two star photometric technique (Grauer and Bond, 1981) for the latter investigation. Landolt's several hundred incompletely analyzed single channel data show no obvious periodicities. There is no doubt that the star was constant during the short interval that it was observed by Grauer et al. Hill et al. also were able to place reasonable limits on its maximum variability, if such exists. BD+10°2179 may be similar to BD-9°4395 which does show on-again, off-again changes in brightness. Additional observations are in order. They should be all-night, several days in a row, in three or four different seasons kind of observations. That way one will have access to as homogeneous a data string as possible. And for the best accuracy, the data should be collected with a two star photometer.

II.6. LSS 1922 = CPD-58°2721

Drilling (1980) found LSS 1922 to be an extreme helium star. Its spectrum proved similar to that of υ Sgr. Heber and Schönberner (1981) derived an effective temperature of 14,500°K. LSS 1922 has a close companion ($\Delta\alpha$ = 0^{s}6 west, and $\Delta\delta$ = 11" south; $\rho \sim$ 13" , $\theta \sim 195^0$) which may affect photometric observations. Landolt has found the companion's magnitude and color indices to be V = 12.648 ± 0.006, (B-V) = +0.661 ± 0.004, (U-B) = +0.092 ± 0.000, (V-R) = +0.400 ± 0.022, (R-I) = +0.371 ± 0.013, and (V-I) = +0.769 ± 0.018 from three measures. The broad band photoelectric data in Table I for LSS 1922 are the averages of thirteen measures obtained over a thirty eight month (1978-81) interval by Landolt. They indicate that LSS 1922 varies by 0^m.15 in V, and confirm the recent announcement by Hill, Jeffery, and Morrison (1985) that LSS 1922 is a semi-regular light and color variable star. This group found a 0.07 mag variation in V, and a 0.07 mag variation in Stromgren's (u-b), all with a cycle time of about 17 days.

II.7. LSS 3184

This star was discovered to be an extreme helium star by Drilling (1985). At the time of writing, modern photometry was not available. The magnitude quoted by Stephenson and Sanduleak (1971) was m_{pg} = 11.9.

II.8. HD 124448 = CoD-45°9033 = CPD-45°6748

Popper (1942) discovered and discussed this star's observational characteristics (Popper 1946, 1947), doing so at the McDonald Observatory's 82 inch telescope by sighting southward through the mesquite bushes and cactus. His description of a stellar spectrum dominated by helium spectral lines and lacking any trace of hydrogen marks this star as the first known member of the extreme helium star group. Hill (1964) quoted early UBV photometry by Wesselink: V = 9.98, (B-V) = -0.07 and (U-B) = -0.80. Hill (1964, 1965) also derived relative abundances in HD 124448's atmosphere via a curve of growth analysis. Later photometry (Hill 1969b) found V = 9.99, (B-V) = -0.09, and (U-B) = -0.80, in good agreement with Wesselink's values.

Landolt (1973a) published UBV photometry covering the time interval 1969-72. His limited data indicated possible light variability up to several hundredths of a magnitude. Some hundreds of subsequent differential unpublished observations by Landolt indicate constancy to better than the two percent level. Walker and Kilkenny (1980), based on their observation that the standard deviation in V for HD 124448 is nearly double that for the comparison star that they used, also lean toward believing that the star is a small amplitude variable. On the other hand, Hill et al. (1984) say that their data show no light variation.

II.9. LSS 3378 = CoD-48°10153 = CPD-48°7730

Drilling (1973) found star 3378 in the catalogue of Stephenson and Sanduleak (1971) to be a helium-rich B star. He showed that LSS 3378's spectrum fitted the description of stars in the helium star class (Dinger 1970). The star's magnitude and colors were found to be V = 11.48, (B-V) = +0.43, and (U-B) = -0.31 from two measures obtained at CTIO. Drilling was able to show that the absolute magnitude might fall in the interval $-4 < M_V < -1.5$.

The results of Landolt's long term (1975-81) monitoring of LSS 3378 are shown in Table I, agreeing fortuitously with Drilling's initial values. Forty differential UBV observations obtained on 8 June 1977 U.T. indicate that LSS 3378 varies at optical wavelengths. The data may be interpreted to imply a quasi-periodicity on the order of several minutes superposed on a longer-term variation of perhaps $0^d.243$. The total amplitude is 0.06 magnitude for the shorter term variation and about 0.1 magnitude for the longer term variation. Two other nights with fewer data points also show evidence for light variation, but in a more subdued manner. The star deserves detailed photometric attention.

Drilling et al. (1984) found LSS 3378 to be one of the coolest of the extreme helium stars, with an $T_e \sim 9200$ °K. Heber and Schönberner (1981) and Drilling, Landolt, and Schönberner (1984) found the star to be heavily reddened by appreciably more than one magnitude of absorption.

II.10. BD-9°4395

MacConnell et al. (1972) found BD-9°4395 to be a hydrogen-deficient star during an objective prism survey. An abundance analysis by Kaufmann and Schönberner (1975, 1977) showed that BD-

9°4395 was an extreme helium star. They found the star's mass to fall in the range 0.6 - 0.9 solar mass and its luminosity to be on the order of log $L/L_\odot$ = 4.25. Schönberner et al. (1982) determined the color excess to be E_{B-V} = 0.30 and found an effective temperature of 23,500 °K.

A summary of the star's photometry is in Table I. Landolt found the star to be variable in light in data taken on 13 June 1978 UT; subsequent observations by Grauer and Landolt using a two-star photometer failed to find any hint of photometric changes. Landolt and Grauer (1985) have determined that the light variations showing a maximum amplitude of 0.06 magnitude are quite complex. Quotes in the literature of other unpublished data confirm this (see Jeffery and Malaney, 1985).

II.11. LSS 4300 = CoD-35°11760 = HDE 320156 = CPD-35°7069

Drilling (1980) found LSS 4300 to be an extreme helium star during a spectroscopic survey of OB+ stars. Schonberner and Drilling (1984) showed LSS 4300 to be a high-temperature analogue of the hydrogen-deficient binaries υ Sgr and KS Per. Broad-band JHKL photometry revealed an infrared excess nearly identical to that of υ Sgr. Schönberner and Drilling suggested that LSS 4300 also is a close binary system containing a helium supergiant component along with a less luminous secondary. They believe that the latter is accreting matter from the primary.

Landolt has accumulated fifteen multicolor UBVRI observations of LSS 4300 over a 1,229 day interval. The data are summarized in Table I. The suspected binary ranges in brightness from V = 9.71 to 9.86. The color, too, changes by about 0.1 magnitude. The data indicate a maximum change in brightness in a time interval as short as one day. While the data hint at a period of 65 days, two data points do fall well off the phased light curve. Hence, like both υ Sgr and KS Per, LSS 4300 may be a low amplitude eclipsing system.

LSS 4300 is star number 8849 in the Cape Photographic Catalogue (Cape Annals 18, p. 177). One finds therein the star's proper motion values to be $\tilde{\mu}_\alpha = -0\rlap{.}''4$ and $\mu_\delta = -2\rlap{.}''7$ per 100 years.

II.12. HD 160641

The second helium star to be discovered was found by Bidelman (1952). Hill (1969b) found the star's magnitude and colors to be V = 9.86, (B-V) = +0.15 and (U-B) = -0.85. Extensive monitoring of HD 160641 in the interval 1968-72 showed the star to be variable in light (Landolt 1973a, 1975). An amplitude up to a tenth of a magnitude was evident. A period of perhaps 0.6 days was suggested. Additional unpublished data obtained in the intervening years corroborate the discovery results. Clean-cut periodicities, however, do not exist. Other observers' unpublished data, as quoted by Jeffery and Malaney

(1985), confirm these conclusions. Walker and Kilkenny (1980) have uvby data which suggests a 0.71 day "period", but they, too, note that the concept of a simple period most likely does not apply to HD 160641. A preprint (Lynas-Gray et al. 1985) indicates that "observed pulsation frequencies have been found which are consistent with $\ell = 4$ fundamental mode pulsation of a one solar mass extreme helium star".

II.13. LSS 4357

This extreme helium star was discovered by Drilling (1985). The available photometry is presented in Table I, and was obtained by Landolt in September, 1985 at the CTIO telescopes. The data are too few to address the question of light variability. They do indicate, however, by analogy to other stars in the table, a reddening of perhaps 0.3 magnitude.

II.14. LSIV-1°2

The star LSIV-1°2 was discovered by Drilling (1980) to be an extreme helium star. He found its spectrum to be nearly identical to that of HD 168476, for which Schonberner and Wolf (1974) give an effective temperature of 13,500°K. Drilling (1975) acquired broad band photometry which provided V = 10.99, (B-V) = +0.36, and (U-B) = -0.47. These values agree well with Landolt's data in Table I in this paper. The star should be observed for possible optical variations.

II.15. BD-1°3438 = LSIV-1°3

The extreme helium star BD-1°3438 was discovered by MacConnell et al. (1972) on blue objective prism plates taken with the Curtis Schmidt telescope at CTIO. In addition to pointing out BD-1°3438's similarity to other then known hydrogen deficient stars, MacConnell and colleagues provided the first UBV photometry: V = 10.42, (B-V) = +0.43, and (U-B) = -0.29. They noted that this star suffers appreciable absorption, when compared to other extreme helium stars. This was verified by Heber and Schönberner (1981) and refined by Schönberner et al. (1982); the latter group found $E_{B-V} = 0.40$.

Landolt has 66 unpublished UBV observations on three nights which by themselves are not sufficient to establish variability. His average magnitude and colors, though, of V = 10.328, (B-V) = +0.460 and (U-B) = -0.246 differ substantially from the discovery values determined by MacConnell et al. (1972). Hill (1985) writes that there is evidence for a mixture of long and short periods. In the sense of long term photometric behavior, BD-1°3438 may be similar to HD 168476. These two stars also are similar in temperature.

II.16. HD 168476 = CoD-56°7300 = CPD-56°8755

Thackeray and Wesselink (1952) found HD 168476 to be a helium star. The latter's photometry, quoted by Hill (1964), showed the star's brightness and colors to be V = 9.37, (B-V) = -0.01, and (U-B) = -0.67. Later photometry (Hill, 1969b) showed the star to be somewhat brighter at V = 9.30 but unchanged in colors: (B-V) = -0.01 and (U-B) = -0.69. Spectroscopic investigations (Hill, 1964, 1965) were carried out in the same time interval. HD 168476 is catalogued as CPC 5911 in the Cape Annals, volume 20, wherein one finds proper motion values of $\mu_\alpha = -0\overset{''}{.}8$ and $\mu_\delta = +1\overset{''}{.}1$ per 100 years. Landolt's (1973a) UBV data seemed to indicate a small secular brightening for HD 168476 when compared to Hill's results. Walker and Kilkenny (1980) published Stromgren uvby data which, together with previous published photometry, indicated variability on a long time scale. The author's unpublished data tend to reinforce the idea of a long-term trend. These photometric variations appear to be complex. Walker and Hill (1985) also have found the radial velocity variations of HD 168476 to be of a complex nature.

II.17. LSS 5121

Star number 5121 of the Stephenson and Sanduleak (1971) catalogue was discovered to be an extreme helium star by Drilling (1985). Photometry done by Landolt at the CTIO telescopes in September, 1985 resulted in the magnitude and colors in Table I. One can estimate from these data that LSS 5121 has a color excess E_{B-V} of 0.2 - 0.3 magnitude.

II.18. LSIV-14°109

The star LSIV-14°109 was discovered to be an extreme helium star by Drilling (1979). He found its effective temperature to be a bit less than 13000°K. Drilling's (1975) broadband magnitude and color indices for LSIV-14°109 are V = 11.19, (B-V) = +0.31, and (U-B) = -0.31. These compare to Landolt's measures in Table I herein of V = 11.152, (B-V) = +0.33, and (U-B) = -0.277. There really are not sufficient data to indicate variability, although similar differences for other objects among the extreme helium star group are deemed indicative of variability.

II.19. υ Sgr = 46 Sgr = HR 7342 = BD-16°5283 = HD 181615

The star υ Sgr is one of the classical members of the hydrogen-deficient binary star group; the other is KS Per. The UBV photometry for this star in Table I was taken from Johnson et al. (1966). Other Johnson photometric system colors are (V-R) = +0.27 and (R-I) = +0.13.

υ Sgr was discovered to be an eclipsing binary by Gaposchkin (1944). Eggen, Kron, and Greenstein (1950) obtained the first photoelectric light curve. The binary has a period of 137.939 days.

Table I

Broad-band Photometry for the Extreme Helium Stars

Star	V	B-V	U-B	V-R	R-I	E_{B-V}
BD+37°442	9.991	-0.294	-1.149			
HD 30353	7.85	+0.49	-0.16			
LSS 99	12.289	+0.700	-0.295	+0.445	+0.474	
BD+37°1977	10.21					
BD+10°2179	9.948	-0.191	-0.859			0.00
LSS 1922	10.495	+0.721	-0.169	+0.562	+0.596	0.70
LSS 3184	11.9					
HD 124448	9.980	-0.097	-0.775			0.08
LSS 3378	11.483	+0.440	-0.318	+0.329	+0.306	0.35
BD-9°4395	10.535	+0.055	-0.833			0.30
LSS 4300	9.779	+0.839	-0.133	+0.614	+0.654	
HD 160641	9.825	+0.144	-0.802			0.40
LSS 4357	12.620	+0.412	-0.521	+0.288	+0.284	
LSIV-1°2	11.009	+0.375	-0.485	+0.264	+0.284	0.45
BD-1°3438	10.328	+0.460	-0.246			0.40
HD 168476	9.268	-0.012	-0.666			0.13
LSS 5121	13.253	+0.316	-0.699	+0.212	+0.227	
LSIV-14°109	11.152	+0.331	-0.277	+0.298	+0.250	0.20
υ Sgr	4.61	+0.10	-0.53			
LSII+33°5	10.307	+0.160	-0.754	+0.086	+0.092	0.25
LSIV+2°13	9.557	+0.188	-0.536	+0.134	+0.107	0.15

The amplitude of the light variation is about 0.1 magnitude. Irregularities occur in the light variation. Photometry of the system also indicates the presence of a large infrared excess.

A modern accurate multicolor light curve would be desirable. The task will be difficult since the period is long, and the system is bright.

II.20. LSII+33°5

The star LSII+33°5 was found to be a hydrogen-deficient star by Drilling (1978). He found this object to differ from other extreme helium stars in that numerous, strong O II lines were observed in its spectrum. Drilling (1975) obtained UBV photometry of LSII+33°5, and found V = 10.43, (B-V) = +0.13, and (U-B) = -0.75. As one can see in Table I, the V magnitude obtained by Landolt is quite discrepant, although two of his four measures were obtained at an extreme air mass. Even neglecting the high air mass observations, however, the magnitude difference still remains about 0.1 magnitude. There is a reasonable chance, then, that LSII+33°5 is variable in light. Additional evidence for light variability may have been recorded in small differences noted between two sets of IUE observations (Drilling et al. 1984).

II.21. LSIV+2°13 = BD+1°4381

BD+1°4381 was discovered to be a hydrogen-deficient star by Drilling (1979). He concluded that it had an effective temperature similar to that of υ Sgr (~ 13,000°K, Heber and Schönberner 1981), but a smaller hydrogen abundance. Photometry by Drilling (1975) found the broadband magnitude and colors of BD+1°4381 to be V = 9.56, (B-V) = +0.18, and (U-B) = -0.56. These values agree with similar photometry by Landolt in Table I in this paper. An effective temperature of 9500 °K (Drilling et al. 1984) makes BD+1°4381 one of the coolest known extreme helium stars. Jeffery and Malaney (1985) have published Stromgren uvby photometry for BD+1°4381 which appears to show light variations with an amplitude of $0^m.04$ on a time-scale of perhaps 20 days. Their mean V magnitude, 9.525 ± 0.018 resulting from 47 observations, is $0^m.032$ brighter than Landolt's mean V = 9.557 ± 0.025 in Table I herein, a value resulting from six measures over two years. If one was not expecting the star to be variable in light, one might discount the observed differences, especially since the zero point of the uvby y magnitude historically has not been well established. On the other hand, the mean errors of a single observation are about twice what one would expect for a star of this brightness when measured at 0.4 - 0.9-m telescopes. As Jeffery and Malaney suggest, additional data covering a time span much longer than the suggested 20 day period are needed. Further, given the tiny apparent amplitude of light variation, a two star photometer ought to be used for the data acquisition.

III. SUMMARY

Three stars sometimes included in the extreme helium star group and certainly related, have not been discussed in this paper: BD+13°3224, MV Sgr, and V 348 Sgr. The latter two stars are hot R CrB stars. A review of V 348 Sgr is given in a recent paper by Heck, et al. (1985). It is noted therein that V 348 Sgr ranges from V = 12th to 18th magnitude, values confirmed by the author's unpublished photometry. MV Sgr has been undergoing small scale light variations during recent years. The author's UBVRI photometry indicates that V = 13.09, (B-V) = +0.26, (U-B) = -0.57, (V-R) = +0.23, (R-I) = +0.41, and (V-I) = +0.67. The total range in the V magnitude has been 0.26 magnitude. It should be noted that the fainter than normal observation of MV Sgr reported by the author (Landolt 1979b) almost certainly was a misidentification at the telescope.

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