II. B A S I C D A T A

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BASIC DATA ON HYDROGEN-DEFICIENT STARS

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ABSTRACT. The current state of our knowledge on the distribution and motions of various types of hydrogen-deficient stars, and of their positions in the H-R diagram, is reviewed. It is concluded that the extreme helium stars (with the exception of the H-deficient binaries) and cool hydrogen-deficient stars belong to the population of the Galactic nuclear bulge, whereas the intermediate helium stars are young stars of Population I. The helium-rich sdO stars appear to be a local sample which is predominantly Population I.

1. INTRODUCTION.

This review will cover the basic data (classification, surveys, distribution, motions, effective temperatures, and absolute magnitudes) of hot extreme helium stars (including the hydrogen-deficient binaries), cool hydrogen-deficient stars, intermediate helium stars, and helium-rich subdwarf O stars. The positions of these objects in the Hertzsprung-Russell diagram, as well as they can be determined at present, are given in Fig. 1. The helium-rich white dwarfs (which lie below the objects shown in Fig. 1), and helium-rich central stars of planetary nebulae (which lie to the left of most of the objects shown in Fig. 1) will be discussed elsewhere in this volume.

2. HOT EXTREME HELIUM STARS

The hot extreme helium stars are characterized by strong lines of HeI and weak or absent Balmer lines at a spectral resolution of 2 Å (Hunger 1975). This definition also includes some of the helium-rich sdO stars which, however, also show evidence of higher surface gravities. At the much lower resolution of the Case-Hamburg OB star surveys (see Stephenson and Sanduleak 1971), the spectra have a nearly featureless appearance, and are classified as OB+. It has thus been possible to obtain a complete sample of extreme helium stars down to

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photographic magnitude 12 by observing at a resolution of 2 Å or better all of the OB+ stars in the Case-Hamburg surveys (which cover the entire Milky Way) and their extension to b = ±30° for ℓ = ±60° (Drilling 1980). This sample, along with all of the other known extreme helium stars, is given in Table A1 (in the appendix) along with equatorial coordinates for 2000.0, galactic coordinates, V magnitudes, B-V colors, and heliocentric radial velocities (when known).

In Fig. 2, the distribution of these objects on the sky is shown. As mentioned above, the sample is complete down to photographic magnitude 12 within the area of the sky covered by the Case-Hamburg surveys and their extension by Drilling to b = ±30° for ℓ = ±60° (indicated by the solid lines in Figure 2). If one compares this figure with Fig. II-1 of Pottasch (1984), it is seen that the distribution of extreme helium stars is very similar to that of planetary nebulae with angular diameters less than 12", indicating that most of the extreme helium stars belong to the stellar population of the Galactic nuclear bulge (Whitford 1985).

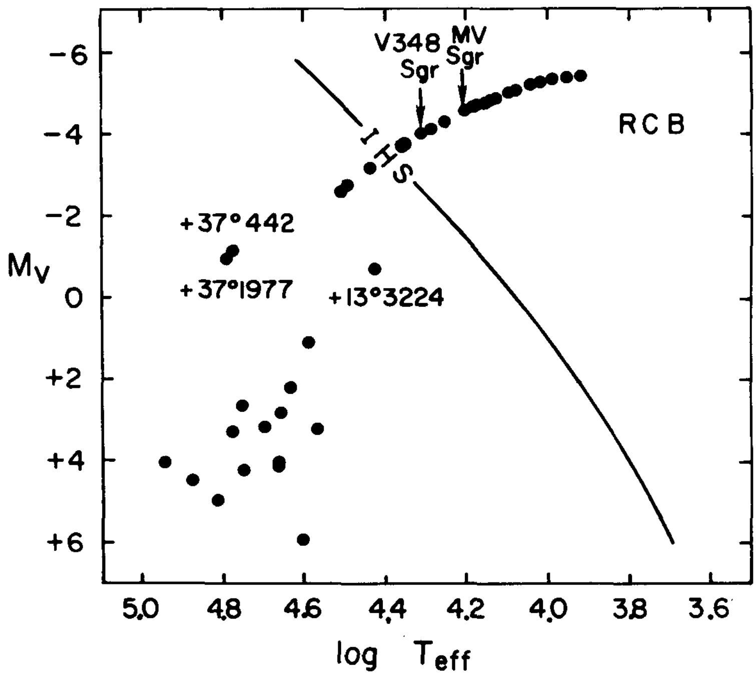

Figure 1. Hertzsprung-Russell diagram showing the positions of the cool hydrogen-deficient stars (RCB), intermediate helium stars (IHS), extreme helium stars (dots in upper half of figure), and helium-rich sdO stars (dots in lower half of figure). The position of the main sequence (solid curve) is also shown.

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This conclusion is reinforced by Fig. 3 which shows the radial velocities given in Table A1 plotted against galactic longitude. The radial velocities have been corrected for the basic solar motion in all cases. The solid curves are the relations given by Pottasch (1984) for the expected radial velocities of objects at three different distances from the sun which are traveling in circular orbits about the galactic center. Comparison with Fig. II-5 of Pottasch (1984) shows that the velocity distribution of the extreme helium stars is very similar to that of planetary nebulae whose angular diameters are less than 20" and which lie within 10° of the galactic plane. These objects have a velocity dispersion of 140 km/sec in the direction of the galactic center, which again indicates that they belong to the bulge population, and could therefore not have had initial masses larger than one solar mass.

Three of the objects included in Table A1 and Figs. 2 and 3, MV Sgr, V348 Sgr, and DY Cen, show R CrB-type light variations (see next section). Near maximum light, MV Sgr fits the spectroscopic definition given above for the extreme helium stars, but shows in addition a number of weak, narrow emission lines (Herbig 1964). V348 Sgr has a predominantly emission-line spectrum at maximum light, with strong HeI and CII and little or no (stellar) contribution from the Balmer lines (Herbig 1958, Houziaux 1968, Dahari and Osterbrock 1984). Low-resolution IUE spectra of V348 Sgr in the wavelength region 1200-3000 Å are very similar to those of HD 124448 and HDE 225642 (Heber et al. 1984). The spectrum of DY Cen, for which

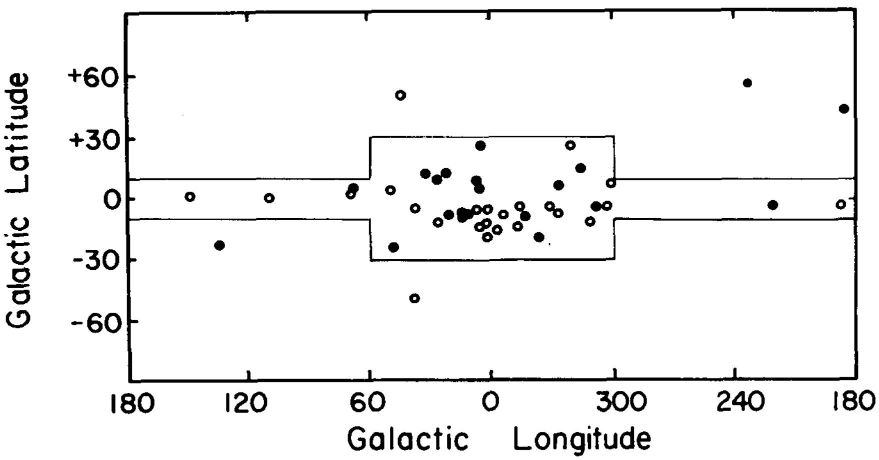

Figure 2. The distribution of extreme helium stars (filled circles) and cool hydrogen-deficient stars (open circles) on the sky. The boundaries of the Case-Hamburg OB star survey and its extension are shown by the solid lines.

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Kilkenny and Whittet (1984) find T(eff) = 10,000°K, shows Hδ ≈ HeI 4026 and strong carbon features (Hill 1986).

The four H-deficient binaries (υ Sgr, KS Per, HDE 320156 and CPD -58°2721) have been included in Table A1, but are not plotted in Figs. 2 and 3. These stars fit the spectroscopic definition given above, but differ from the other extreme helium stars in the following ways: (a) the visible spectra indicate that they are single-lined spectroscopic binaries (the companions have been detected in the UV in two cases), (b) the N/C atmospheric abundance ratios are considerably higher, (c) the spectra show strong Hα emission, (d) in two cases there is a large infrared excess, (e) the system radial velocities are close to those expected for circular orbits about the galactic center, and (f) the distances from the galactic plane are less than 200 pc (see Drilling 1980; Drilling and Schönberner 1982; Schönberner and Drilling 1983; Schönberner and Drilling 1984; Rao and Venugopal 1985; Drilling, Heber, and Jefferey 1985; Jeffery and Drilling 1986). These stars, unlike the other extreme helium stars, appear to be relatively young stars of Population I, and therefore must have had larger initial masses than the other extreme helium stars to be seen at present in a similar evolutionary state.

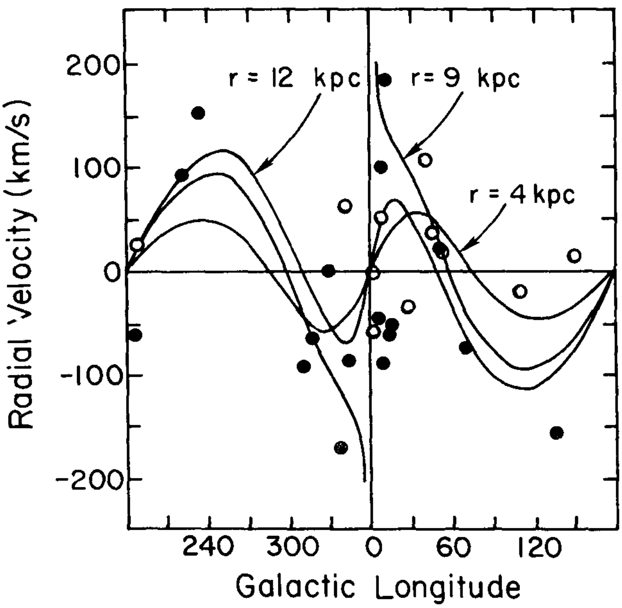

Figure 3. Radial velocity (corrected for basic solar motion) vs. galactic longitude for extreme helium stars (filled circles) and cool hydrogen-deficient stars (open circles). The solid curves are the expected loci of objects at three different distances from the sun which are traveling in circular orbits about the galactic center (Pottasch 1984).

The peculiar object V652 Her (BD+13°3224) has also been included in Table A1 but is not plotted in Figs. 2 and 3. V652 Her fits the spectroscopic definition given above, but appears to be less luminous and less helium-rich than the other extreme helium stars and, unlike the other objects listed in Table A1, is a regular pulsating variable with a period of 0.108 days (Hill et al. 1981). Like the hydrogen-deficient binaries, V652 Her appears to have a much higher N/C abundance ratio than the other objects listed in Table A1. The effective temperature and absolute magnitude used to plot V652 Her in Fig. 1 are those given by Hill et al. (1981).

Unless otherwise noted, the effective temperatures used to plot the objects listed in Table A1 in Fig. 1 are those determined by Drilling et al. (1984) or by Schönberner et al. (1982) from the observed continuous energy distribution between 1200 and 34,000 Å. In all but two cases, the strength of the 2200 Å interstellar feature and the Seaton (1979) reddening law were used to correct for the effects of interstellar absorption, and helium-rich model atmospheres used to estimate both the angular diameters and the flux shortward of 1200 Å. In the cases of the H-deficient binaries υ Sgr and KS Per, the effective temperatures of the primary components were determined by fitting the model atmospheres directly to the dereddened continua. Similar methods were used by Darius, Gidding, and Wilson (1979) to determine the effective temperatures of BD+37°442 and BD+37°1977 from low-resolution IUE spectra. In six of the above cases effective temperatures have also been determined by the fine analysis of high-resolution line spectra (Wolff, Pilachowski, and Wolstencroft 1974; Schönberner and Wolf 1974; Kaufmann and Schönberner 1977; Schönberner 1978; Walker and Schönberner 1981; Heber 1983) and the agreement is quite satisfactory. The effective temperature of HDE 320156 has also been determined by the fine analysis of high-resolution line spectra (Schönberner and Drilling 1984), and Heber et al. (1984) have concluded that T(eff) = 15,000 - 16,000°K for V348 Sgr from the similarity of its low-resolution IUE spectrum to those of HD 124448 and HDE 225642. Drilling (1986) has estimated the effective temperatures of LSS 99, LSS 3184, LSS 4357, LSIV+6°2, and LSS 5121 from the similarity of their low resolution optical spectra to those of other objects listed in Table A1.

In plotting the objects listed in Table A1 in Fig. 1, it has been assumed that all of them except V652 Her have the Schönberner luminosity, log (L/L_O) = 4.1. This luminosity is consistent with the positions in the log T(eff) - log g plane of the 6 extreme helium stars and 3 R CrB stars whose positions are known from the fine analysis of high-resolution spectra (see Walker and Schönberner 1981), and with the post-AGB evolutionary tracks computed by Schönberner (1977). Bolometric corrections were determined from the effective temperatures using Planck's Law, and do not differ significantly from those given by the helium-rich model atmospheres used by Schönberner et al. (1982) and Drilling et al. (1984). The absolute magnitudes obtained in this way are not significantly different from those obtained for υ Sgr (M_V = -4.8 ± 1.0; Rao and Venugopal 1985) and CPD-58°2721 (M_V = -5.0 ± 1.0, Drilling 1986) from the distribution of interstellar reddening, polarization, and interstellar line strength for nearby stars. They are also consistent with M_V = -5.4 for BE 202, which lies in Large Magellanic Cloud, if it is assumed that this star is similar to the hydrogen-deficient binaries (Bohannon 1981). Finally, they are consistent with the mean absolute magnitude of R CrB stars in the LMC, -4.4 ± 0.6 (Feast 1972).

3. COOL HYDROGEN-DEFICIENT STARS

The R CrB variables are stars which undergo irregular decreases in light of as much as 9 magnitudes in a few weeks. The relatively rapid decrease is followed by a slower return to maximum light, where the star spends most of its time. There are, in fact, stars which are spectroscopically identical to the cool R CrB stars which have never been observed to vary in light, the so-called non-variable hydrogen-deficient carbon (HdC) stars (Bidelman 1953, Warner 1967). At a spectroscopic resolution of 2 Å, both the cool R CrB stars and non-variable HdC stars show strong carbon features (except for CH, which is very weak) and very weak Balmer lines. All stars which fit the spectroscopic definition given above are listed in Table A2, along with equatorial coordinates for 2000.0, galactic coordinates, V magnitudes, B-V colors, and heliocentric radial velocities (when known). According to Warner (1967), HD 148839 is not as hydrogen-deficient as the other stars listed in Table A2, and may represent a type intermediate to the cool hydrogen-deficient stars and normal carbon stars.

The distribution on the sky of the objects listed in Table A2 is shown in Fig. 2, along with that of the extreme helium stars. All but 5 of these objects are R CrB stars, which are relatively easy to discover because of the large light variations. The sample is, however, effected by the incompleteness of the variable star surveys. The non-variable HdC stars are much harder to pick out because spectra of 2 Å resolution or better are required to identify them. For this reason, Warner (1967) has estimated that their space densities may actually be on the order of 10 times greater than those of the R CrB stars. Taking these selection effects into account, we conclude that the cool hydrogen-deficient stars also have a space distribution which is similar to that of the distant planetary nebulae, i.e. that most of them belong to the population of the Galactic nuclear bulge. The known radial velocities of cool hydrogen-deficient stars (corrected for the basic solar motion) are plotted against galactic longitude in Fig. 3, along with those of the extreme helium stars. Again, the radial velocities reinforce the conclusion that we are dealing with the bulge population, but the case is not as strong as it is for the extreme helium stars.

The effective temperatures used to define the locus of the cool hydrogen-deficient stars in Fig. 1 are those given by Kilkenny and Whittet (1984), which were determined by fitting Planck's Law to the continuous energy distributions of 10 cool RCrB stars as determined from UBVRIJHKLMNQ photometry. Color excesses were determined using published maps of the color excess and assuming that all of the cool hydrogen-deficient stars lie beyond the absorbing layer. The observed colors were then corrected for interstellar reddening using van de Hulst's curve No. 15 (Johnson 1968). Schönberner (1977) has determined effective temperatures for three cool RCrB stars from the fine analysis of high-resolution spectra. He finds an effective temperature for RY Sgr, the one star in common to the two studies, which is 900°K higher than that found by Kilkenny and Whittet. The absolute magnitudes used to define the locus of the cool hydrogen-deficient stars in Fig. 1 are those given by Feast (1972) for the three R CrB stars which lie in the Large Magellanic Cloud.

4. INTERMEDIATE HELIUM STARS

The spectra of intermediate helium stars are similar to those of normal stars of MK spectral type B2V, but have abnormally high HeI/H line strengths (Walborn 1983). Because the Balmer lines are stronger than they are in the case of the extreme helium stars, they can be seen at the resolution of the OB star surveys, where the intermediate helium stars are usually classified as OB or OB^-. A much higher resolution (2 Å) is, however, needed to resolve the helium lines and separate these objects from normal stars with spectral types near B2V. For this reason, the sample of intermediate helium stars is only complete down to the limiting magnitude of the HD catalog ($B \sim 8.5$), for which most of the early-type stars have been observed at higher resolution. The sample of intermediate helium stars is complete to B = 10 for the southern sky because of the surveys of MacConnell, Frye, and Bidelman (1970) and Garrison, Hiltner, and Schildt (1977). The problem of completeness is complicated by the fact that the helium spectra are sometimes variable, in one case going from normal to pronouncedly helium-rich and back in less than 10 days (Bond and Levato 1976).

All of the known intermediate helium stars have been listed by Walborn (1983), and this list is repeated in Table A3 along with the 2000.0 equatorial coordinates, galactic coordinates, V magnitudes, B-V colors, and heliocentric radial velocities (when known). According to Walborn (1983) and Hunger (1975), HD 144941 is intermediate to the extreme and intermediate helium stars according to the spectroscopic definitions. Walborn also lists additional objects which he has not confirmed to be helium-rich or which he believes to be related to the intermediate helium stars.

Fig. 4 shows the distribution of known intermediate helium stars on the sky. If we take into account the selection effects mentioned above, it is seen that the brighter objects show a preference for Gould's belt, whereas the fainter objects tend to concentrate towards the galactic plane, but not the galactic center. In Fig. 5, the radial velocities listed in Table A3 are plotted against galactic longitude after correction for the basic solar motion. These stars are seen to have the radial velocities expected for objects moving in circular orbits about the galactic center if they are located within 4 kpc of the sun, which is the case if these stars have the absolute magnitudes of normal B2V stars. That the absolute magnitudes and effective temperatures of these stars are similar to those of normal B2V stars is indicated by the apparent magnitudes and colors of the six stars which are members of associations (Walborn 1983; Drilling 1981) and is consistent with the fine analysis of high-resolution spectra for most of the stars (see Hunger 1975 and in this volume). We conclude that the intermediate helium stars are predominantly young, massive stars of population I. A possible exception is the star SB 939, which is discussed by Langhans, Heber, and Hunger elsewhere in this volume.

5. HELIUM-RICH SUBLUMINOUS O STARS

Like the extreme helium stars, helium-rich sdO stars with $n(H)/n(He) \lesssim 1$ show strong lines of HeI (and/or HeII for the hotter stars) and very weak or absent Balmer lines at a spectral resolution of 2 Å (Greenstein and Sargent 1974; Hunger 1975; Hunger et al. 1981;

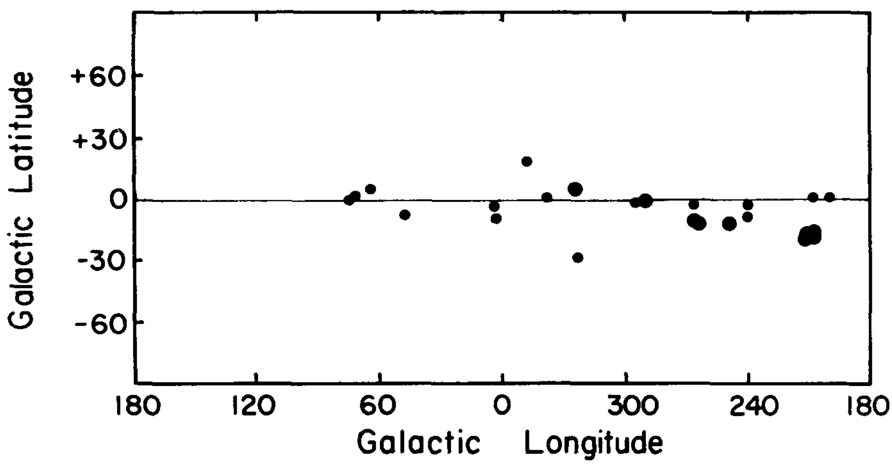

Figure 4. The distribution of intermediate helium stars on the sky. Large dots represent stars with $V < 7.5$, and small dots, stars with $V \geqslant 7.5$.

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Schönberner and Drilling 1984). For this reason, the sample is complete to photographic magnitude 12 for the area of the sky covered by the Case-Hamburg OB star surveys and their extension. Unlike the extreme helium stars, however, the spectra of these stars show evidence of surface gravities greater than log g = 4 (Stark broadened H and He lines and strong HeII 4686). Included in Table A4 are all stars classified by Drilling (1983,1986) as belonging to this category plus all additional helium-rich sdO stars known to this writer which are brighter than B = 14.5.

The distribution of these stars on the sky is shown in Fig. 6. The selection effects mentioned above are very important because very few of the objects brighter than B = 12 lie within the region of the sky covered by the Case-Hamburg surveys or their extension (shown by the solid boundaries in Fig. 6). The excess of faint objects in the Southern Milky Way is undoubtedly due to the superior seeing at Cerro Tololo as compared to that at Hamburg and Cleveland. The clustering of faint objects near the South Galactic Pole is due to the survey of Slettebak and Brundage (1971), which allowed all OB stars brighter than B = 14 to be identified within an 824 square degree region surrounding the South Galactic Pole. Taking all of this into account, one may conclude that we are dealing here with a more-or-less local

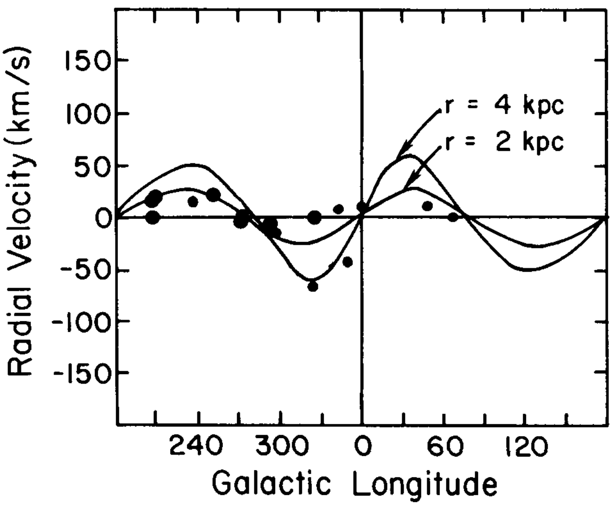

Figure 5. Radial velocity (corrected for basic solar motion) vs. galactic longitude for intermediate helium stars. Large dots represent stars with V < 7.5, and small dots, stars with V > 7.5. The solid curves are the expected loci of objects at two different distances from the sun which are traveling in circular orbits about the galactic center (Pottasch 1984).

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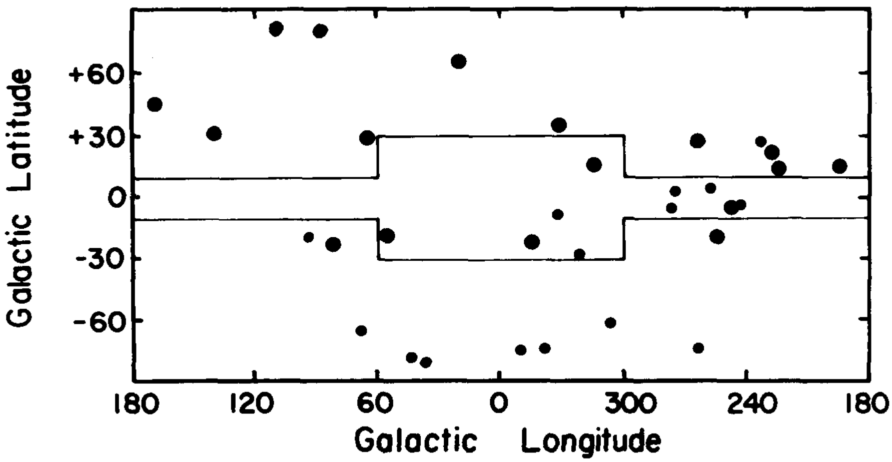

Figure 6. The distribution of helium-rich sdO stars on the sky. Large dots represent stars with V < 12.0, and small dots, stars with V > 12.0. The boundaries of the Case-Hamburg OB star survey and its extension are shown by the solid lines.

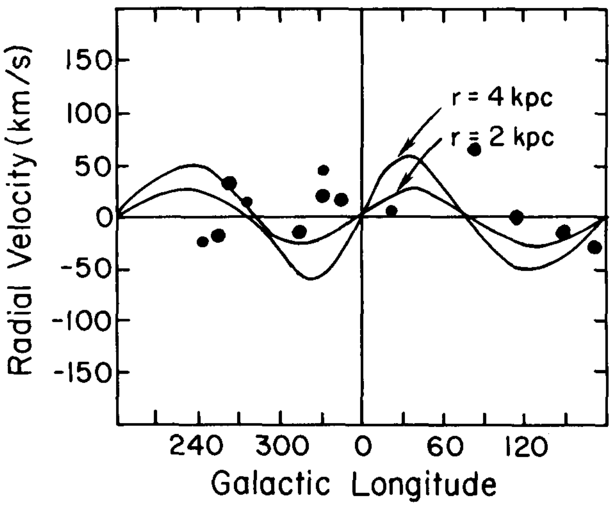

Figure 7. Radial velocity (corrected for basic solar motion) vs. galactic longitude for helium-rich sdO stars. Large dots represent stars with V < 12.0, and small dots, stars with V > 12.0. The solid curves are the expected loci of objects at two different distances from the sun which are traveling in circular orbits about the galactic center (Pottasch 1984).

sample, as one would expect from the absolute magnitudes indicated in Fig. 1. This impression is reinforced by Fig. 7, where the radial velocities given in Table A4 are plotted against galactic longitude after correction for the basic solar motion. Here, the radial velocities tend to cluster around zero to all longitudes, as one would expect for a local sample of objects which more or less share the sun's orbit about the galactic center (i.e. Population I). BD+39°3226, which appears to be a high-velocity star (Dworetsky, Whitelock, and Carnochan 1982), is not plotted in Fig. 7.

The effective temperatures and absolute magnitudes plotted in Fig. 1 are those given by Schönberner and Drilling (1984). For the four hottest objects plotted (LSE 153, LSE 259, LSE 263, and LSIV+10°9), the effective temperatures were determined from the slope of the ultraviolet continuum. The strength of the 2200 Å feature was used along with the Seaton (1979) reddening law and published maps of the color excess in the solar neighborhood to correct for the effects of interstellar reddening and to estimate the distances of these objects. The effective temperatures and surface gravities of the other stars have been determined from the fine analysis of high resolution spectra (Hunger et al. 1981), and the absolute magnitudes were estimated using Schönberner's (1981) bolometric corrections and assuming a mass of 0.5 $M_\odot$.

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REFERENCES

Bidelman, W. P. 1953, *Ap. J.*, **117**, 25.
Bohannon, B. 1981, *Bull. American Astron. Soc.* **13**, 526.
Bond, H. E., and Levato, H. 1976, *Publ. Astron. Soc. Pacific* **88**, 905.
Dahari, O., and Osterbrock, D. E. 1984, *Ap. J.* **277**, 648.
Darius, J., Gidding, J. R., and Wilson, R. 1979, *The First Year of IUE*, p. 36.
Drilling, J. S. 1980, *Ap. J.* **242**, L43.
Drilling, J. S. 1981, *Ap. J.* **250**, 701.
Drilling, J. S. 1983, *Ap. J.* **270**, L13.
Drilling, J. S. 1986, in preparation.
Drilling, J. S., Heber, U., and Jefferey, C. S. 1985, IAU Circular No. 4086.
Drilling, J. S., and Schönberner D. 1982, *Astron. Astrophys.* **113**, L22.
Drilling, J. S., Schönberner, D., Heber, U., and Lynas-Gray, A. E. 1984, *Ap. J.* **278**, 224.
Dworetsky, M. M., Whitelock, P. A., and Carnochan, D. J. 1982, *Mon. Not. R. Astron. Soc.* **201**, 901.

Feast, M. W. 1972, *Mon. Not. R. Astr. Soc.* **158**, 11P.
Garrison, R. F., Hiltner, W. A., and Schild, R. E. 1977, *Ap. J. Suppl.* **35**, 111.
Greenstein, J. L., and Sargent, A. I. 1974, *Ap. J. Suppl.* **28**, 157.
Heber, U. 1983, *Astron. Astrophys.* **118**, 39.
Heber, U., Heck, A., Houziaux, L., Manfroid, J., and Schönberner, D. 1984, *Proc. Fourth European IUE Conference* (ESA SP-218), 367.
Herbig, G. H. 1958, *Ap. J.* **127**, 312.
Herbig, G. H. 1964, *Ap. J.* **140**, 1317.
Hill, P. W. 1986, private communication.
Hill, P. W., Kilkenny, D., Schönberner, D., and Walker, H. J. 1981, *Mon. Not. R. Astr. Soc.* **197**, 81.
Houziaux, L. 1968, *Bull. Astron. Inst. Czech.* **19**, 265.
Hunger, K. 1975, *Problems in Stellar Atmospheres and Envelopes*, eds. B. Baschek, W. H. Kegel, and G. Traving (New York: Springer-Verlag), p. 57.
Hunger, K., Gruschinske, J., Kudritzki, R. P., and Simon, K. P. 1981, *Astron. Astrophys.* **95**, 244.
Jeffery, C. S., and Drilling, J. S. 1986, in preparation.
Johnson, H. L. 1968, *Nebulae and Interstellar Matter*, eds. B. M. Middlehurst and L. H. Allor (University of Chicago Press), p. 167.
Kaufmann, J. P., and Schönberner, D. 1977, *Astron. Astrophys.* **57**, 169.
Kilkenny, D., and Whittet, D. C. B. 1984, *Mon. Not. R. Astr. Soc.* **208**, 25.
MacConnell, D. J., Frye, R. L., and Bidelman, W. P. 1970, *Publ. Astron. Soc. Pacific* **82**, 730.
Pottasch, S. R. 1984, *Planetary Nebulae: A Study of Late Stages of Stellar Evolution* (Dordrecht, Boston, Lancaster: D. Reidel).
Rao, N. K., and Venugopal, V. R. 1985, *J. Astrophys. Astron.* **6**, 101.
Schönberner, D. 1975, *Astron. Astrophys.* **44**, 383.
Schönberner, D. 1977, *Astron. Astrophys.* **57**, 437.
Schönberner, D. 1978, *Mitt. Astron. Gesellschaft* **43**, 266.
Schönberner, D. 1981, *Astron. Astrophys.* **103**, 119.
Schönberner, D., and Drilling, J. S. 1983, *Ap. J.* **268**, 225.
Schönberner, D., and Drilling, J. S. 1984, *Ap. J.* **276**, 229.
Schönberner, D., Drilling, J. S., Lynas-Gray, A. E., and Heber, U. 1982, *Advances in Ultraviolet Astronomy: Four Years of IUE Research* (NASA CP-2238), 593.
Schönberner, D., and Wolf, R. E. A. 1974, *Astron. Astrophys.* **37**, 87.
Seaton, M. J. 1979, *Mon. Not. R. Astr. Soc.* **187**, 73P.
Slettebak, A., and Brundage, R. K. 1971, *Astron. J.* **76**, 338.
Stephenson, C. B., and Sanduleak, N. 1971, *Publ. Warner and Swasey Obs.* **1**, 1.
Walborn, N. R. 1983, *Ap. J.* **268**, 195.
Walker, H. J., and Schönberner, D. 1981, *Astron. Astrophys.* **97**, 291.
Warner, B. 1967, *Mon. Not. R. Astr. Soc.* **137**, 119.
Whitford, A. E. 1985, *Publ. Astron. Soc. Pacific* **97**, 205.
Woolf, S. C., Pilachowski, C. A., and Wolstencroft, R. D. 1974, *Ap. J.* **194**, L83.

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DISCUSSION

FEAST: This is a comment rather than a question. I think DY Cen has a spectrum definitely like a hot star. I don't know what the temperature is, but I would say more like an A-type star.

N.K. RAO: I have been observing this star at CTIO. Herbig has identified several C II lines in absorption and in emission.

FEAST: In addition to W Men there are 2 other R CrB stars in the LMC. W Men and HV 12842 have $M_v \approx -5$, and HV 5637 (which has strong C_2 bands) has $M_v \approx -3$. I am a little worried that you want to call the R CrB stars population II. I would prefer to call them old population I. You are talking about very old metal-deficient objects.

DRILLING: I did not want to imply that they are metal-deficient, but they are old and have a Pop. II distribution.

FEAST: U Aqr has a very high radial velocity. But I think that is the only one.

N.K. RAO: May I add that Prof. Herbig is presently looking into the radial velocities of R CrB stars from both hemispheres. According to him there are only a few stars which have very high velocities, in addition to U Aqr and VZ Sgr, which I remember have about +200 kms^{-1}; both are genuine members of the class. The rest of them are within about 30 kms^{-1}. So they are not as a group of high radial velocity.

DRILLING: I did seem to me that the velocity dispersion for the cooler stars was less than for the extreme helium stars and so perhaps I am wrong to throw them all into the same bag.

LIEBERT: How does the reddening affect the completeness of the more luminous groups - R Cor Bor and Extreme Helium Stars - for these magnitude-limited surveys? (It seems to me from the evidence presented that they may at least include old disk/Pop. I stars as well as Pop. II stars and there may be a considerable selection effect against finding them in the plane.)

DRILLING: The stars are very luminous. For the solar neighbourhood, up to 2 or 4 kpc, I would think the sample would be complete.

LIEBERT: What are the scale heights, based on the statistics that you have, for the extreme helium stars and the cool hydrogen-deficient stars?

DRILLING: I haven't attempted to derive the scale heights because of the small numbers of stars involved.

TUTUKOV: Can you estimate the total numbers of helium rich stars of different types in our galaxy?

DRILLING: Again, I think that would be very difficult to do because of the fact that if they are of population II, they drop off with the cube of the distance as you go away from the galactic center. Incompleteness sets in after about 2 to 4 kpcs from the sun and so I think it's very difficult to determine the variation with distance from the galactic center and hence to determine the total number in the galaxy.

POTTASCH: Can you make a guess?

DRILLING: Brian Warner has made an estimate for the cool hydrogen-deficient stars.

GARRISON: How does the absolute magnitude determined from the 2200 feature compare with the stark broadened profile estimates for the sdO stars?

DRILLING: Heber has been working on this. I believe the result so far is that the absolute magnitudes derived from surface gravities (assuming a mass of 0.5 s.m.) are more luminous than the ones that have been estimated from the 2200 feature.

HEBER: Yes. The absolute magnitudes derived from the line profiles of sdO stars indicate that the stars are in general more luminous than those inferred from the reddening laws. Unfortunately, these discrepancies are very large in a few cases (up to 5 magnitudes).

DRILLING: I have compared low resolution spectra of these stars with those of BD+37°1977, and the line broadening is much greater. So they are certainly less luminous than the extreme helium stars.

N.K.RAO: I remember Dr. Feast measured the cool R CrB stars in the LMC. I thought he came up with the result that the cool R CrB stars are 1 magnitude fainter than the F type stars.

FEAST: I can tell you this afternoon. (Laughter)