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FURTHER DEGENERATE STARS. X.

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ABSTRACT

This list of 51 further degenerate stars includes many faint red degenerates, as well as blue objects, selected by proper motion or color. Observations were made with the multichannel spectrophotometer and with higher-resolution linear sensors. Hydrogen lines are found down to temperatures of 7000 K. A pair containing two red degenerates has a newly measured parallax leading to discussion of some evolutionary problems of wide double white dwarfs. One remarkably carbon-rich high-velocity star near 9000 K presents some astrophysical problems.
Subject headings: spectrophotometry — stars: proper motion — stars: white dwarfs

I. NEW DEGENERATE STARS AND THEIR SELECTION

Palomar 5 m observations of apparently and intrinsically fainter stars have been continued using the multichannel spectrophotometer (MCSP) and the Cassegrain spectrograph with either the SIT system or the University College London image photon counting system (IPCS). The MCSP permits luminosity and spectral classification for most types of degenerates (Greenstein 1976*a*). The spectrograph permits observations of fainter stars at about 10 times higher resolution. The two devices have provided insight on a variety of strange objects. This *Letter* provides a list of 51 degenerates and further data on 18 other previously known objects. A major problem in this further exploration has been the lack of candidates fainter than the Lowell proper-motion survey (Giclas, Burnham, and Thomas 1971). A careful discussion of selection procedures is required so that statistical considerations are not incorrectly drawn.

The stars listed were drawn from the following five sources: (1) The Lowell proper-motion survey with charts to about 16.5 m_{pg}, $\mu \geq 0''.27$ yr^{-1}, and from the Lowell lists of blue stars with smaller motions (G and GD). (2) Stars from the 1.2 m Palomar Schmidt proper-motion survey[1] by Luyten (LP), for a few of which Luyten (1969*a*, 1976) has published charts. A common-proper-motion pair of LP red degenerates has been observed for parallax by van Altena. (3) An important subset of the LP stars have had attention drawn to them by Luyten (1970) because of large reduced proper motion for their color, mainly from his far northern declination zones. Among these are six common-proper-motion pairs containing a red and blue star, making them more easily recognizable on POSS prints. Charts of the LP stars are available on request. (4) Stars from a complete survey of blue stars in fields at high galactic latitude made by Green (1977), labeled PG, for which charts will be published. (5) A further complete list of objects found by blue color by HS based on *UGR* photometry on 1.2 m Schmidt plates taken by U. Steinlin, near high-latitude Selected Areas and M5. The full lists and charts will be published (Steppe 1977), extend to magnitude 19, and are believed complete for $U - G \leq 1.0$, corresponding to broad-band $U - B \leq -0.25$. In Table 1 the *UBV* colors and *V* magnitudes are estimated on the basis of Steinlin's (1968) transformations derived for main-sequence stars.[2] Of 2100 stars so found, MCSP or SIT observations have been made on 19 of a list of 74 with $U - G < 0.0$. In résumé, we have some red, yellow, and blue stars selected by proper motion and some color-selected blue degenerates, the latter with the prospect of statistical completeness to 15.5 (Green) or 19 (Steppe). Among the Basel survey selection we have found, but not listed here, blue emission-line galaxies and quasars.

Table 1 gives the results, with footnotes explaining the details and references. The name is given preferentially to sources where charts are found. TN and TS are the Tonantzintla blue stars (Iriarte and Chavira 1957; Chavira 1958). The $G - R$ color (col. [4]) is a good MCSP indicator of luminosity, and in column (5)

[1] We are grateful to Roger Angel, William Romanishin, and Charles Kowal for taking repeat photographs at the 1.2 m Schmidt, thus permitting us to rediscover the LP stars by motion since the epoch of the Sky Survey.

[2] Some minor corrections to *V* and $B - V$ so estimated have been made by Buser on the basis of his nonlinear transformation of *UGR* to *UBV*.

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TABLE 1

DATA CONCERNING DEGENERATE STARS OBSERVED WITH THE MCSP OR CASSEGRAIN SPECTROGRAPH

1	2	3		4	5	6	7	8	9	10	11	12
Gr	Name	α	δ	G-R	M_V	V	B-V	Type	Sp.	H_V	So.	Remarks
406	G267-18	00 00.1	-34 30.0	...	*	(14.90)	.46	DC	2	14.3	1,11	LTT3; SIT featureless.
407	GD9	00 58.5	-04 27.5	- .63	11.1	15.3	.03	DA	3	9.4	2,3	PHL 940
408	LP170-1B	01 01.0	+86 40	...	*	(16.7)	a	DC	2	(12.6)	4	cp dM; λ4670?
409	PG175-39	01 12.0	+10 25.3	- .65	10.4	15.4	...	DB	1	...	5	Stg He I
410	GD275	01 15.9	+52 11.5	...	*	(16.0)	-1	DA	4	(11.9)		
411	LP354-381	02 28.7	+26 56	1.03	15.4	17.6	f-g	DK-C	3	15.8	4	Ca II v wk if real
412	GD283	02 31.9	+57 02.3	...	*	(14.5)	-1	DA	2	(11.3)		
413	G221-2	02 36.4	+74 30.0	...	*	(16.0)	0	DA	2	(13.7)		LP30-203
414	GD426	03 02.2	+62 10.8	...	*	(15)	-1	DA	2	(10.9)		
415	TS372	03 40.3	-24 20	...	...	(14.7)	mv!	DAwk	4	...		
416	TS374	03 41.5	-24 49	...	...	(14.6)	mv!	DA	4	...		
417	LP414-106	04 07.3	+19 47	.80	15.0	17.8	f-g	DC	1	16.5	4	
418	LP358-142	04 19.3	+26 36	.69	14.7	18.8	g	DG:	1	17.1	4	T = 140
419	LP475-247	04 37.8	+09 19	.24	14.0	17.0	a	DAwk	3	16.4	4	V wk H; T = 140; has ft cp
420	G83-43	05 52.1	+10 23.3	...	...	(16.6)	0	DAs	2	(14.4)	4,6	LP476-267
44	G102-39	05 51.1	+12 23.8	- .25	12.2	15.8	.05	DC	3	13.1	7	Pos. close pair; cp +12°937
421	LP33-276	06 00.9	+73 32	.54	14.5	17.9	g-k	DAwk	3	17.4	4	V wk H; T = 179
422	LP5-68B	07 14.8	+82 00	.92	15.3	18.2	a	DG	3	13.3	4	Poor, Mg I, Ca I, Ca II; low T
423	SA51-822	07 20.7	+30 25.2	- .75	10.0	15.1	-.29	DAwk	3	...	8	Hot
321	G234-4	07 28.8	+64 16.0	.70	14.9	16.3	+1	DC	3	13.6	7	
424	SA51-776	07 25.0	+31 50.5	-1.11:	8.8:	17.8	-.85	DCpec	1	...	8	V hot; sdO?
	SA51-59	07 34.0	+30 48.1	...	...	(19.0)	.45	DC??	2	...	8	Poor; possibly QSO.
425	SA51-484	07 37.1	+28 48.3	...	...	(19.4)	.16	DC:	2	...	8	Poor
426	LP542-32	07 47.5	+07 19.7	1.31	16.5	17.1		DC	3	18.6		P v. Alt. $M_{1.85}$ 15.96. T = 144
427	LP542-33	07 47.5	+07 19.7	1.06	15.5	16.8		DC	3	18.2		P v. Alt. $M_{1.85}$ 15.63. T = 144
428	G111-49	07 56.5	+43 43.4	- .09	13.0	16.3	0	DF-C	1	14.0		
429	LP163-121B	08 07.4	+48 25	.36	14.0	18.6	a	DA	3	14.3	4	Poor; cp M2
	AT Cnc	08 25.2	+25 31.3	- .21	12.6:	13.6		DAe:	3			Nova-like. Var. em H. M_V poor.
323	GD96	08 46.0	+34 40.9	.06	13.4	15.7	+.28	DAss	3	11.6	7	TN 953
430	LP60-359A	08 52.4	+63 02	.11	*	(15.7)	a-f	DA+dM	2	(10.9)	4	Composite; cp dM2e.
431	PG197-4	09 39.3	+07 11.1	.15	13.5	14.8		DAwk	1	...	5	
432	GD462	10 06.0	+64 13.3	...	*	(13.5)	-1	DA	2	(9.4)		
433	SA54-79	10 20.6	+31 31.5	...	...	(17.7)	-.18	DA	2	...	8	
434	LP93-21	10 42.9	+59 21	.14	12.5::	18.1	f	λ4670p	3	19.3	4	Extr. strong C_2; T > 1000. See text.
435	G197-35	11 48.8	+54 28.5	-.17	12.8	16.8	-1	DA	1	14.4		T = 100.
86	HZ21	12 11.4	+33 12	-.79	9.8	14.6	-.36	DO	3	9.8	7	
89	G148B4B	12 15.0	+32 21.9	.16	13.8	17.0	.35	DC-F	1	13.8	4	LP320-644B; λ4670? cp dM → 13.9.
256	+14°2513B	12 29.9	+13 51.1	1.56	9.7	16.1		sdM	3	13.3	4,7	LP495-171B; not WD; cp doubtful.
292	GD479	12 41.2	+65 09.4	...	*	(16)	-2	DB	2	(11.9)		He I wk.
389	G61-29	13 03.3	+18 17.0	-.19	12.4?	16.0	-.10	DBe	3	13.7	7	Em. broad; accretion disk?
436	G256-7	13 10.0	+85 18.6	.86	15.1	17.0	0,g-k	DC	1	14.5	4,6	LP7-226. V discrepant.
391	G165-7	13 28.7	+30 45.3	.03	13.3	16.0	.84	DG	3	14.7	6	SIT confirms HS; CH, metals stg.
437	G62-46	13 30.3	+01 32.7	.28	14.0	17.4	.38	DC-DAwk	1	14.5		H v wk or λ4670.
438	LP380-5	13 45.8	+23 50	1.13	15.5	15.8	1.09	DC	3	16.6	9	cp dM4-5; chart USNO.
272	G64-43	14 03.8	-01 05.3	-.38	11.9	15.8	-.05	DB	3	13.0	3	SIT W(4713) = 3 Å.
107	SA82-189	14 15.2	+13 15.9	-.58	10.1	15.3	-.23	DA+dM	1	...	8	Composite, hot; Feige 93.
108	TN197	14 21.5	+31 50	-.76	9.9	15.4	-.12	DA	3	8.7	7	Lick p neg.
439	PG241-29	14 21.9	+02 49	-.65	11.1	16.8	...	DA	1	...	5	
362	G223-63	14 26.1	+61 23.7	.26	13.9	17.0	0	DC	3	14.5	7	LP98-57; SIT, no Ca II, λ4670?
296	TN210	14 34.5	+28 57	-.92	9.2	15.9	mv	DA	3	...	7	
440	M5-228	15 14.7	+03 21.4	-.22	12.2	14.0	-.06	DAwk	1	...	8	H wk for color, comp?
366	GD352	15 50.4	+62 36.2	-.04	12.3	16.9	-1	DC?	3	12.8	7	Unidentified wk features suspected. Var.?
441	G227-5	17 28.0	+56 00.5	-.53	11.1	16.4	0	DB	1	13.5	6	T = 146. HS call DC.
442	GD539	19 58.1	+67 32.1	-.79	10.1	16.2	-1	DA	1	12.1		T = 119.
443	GD 544	20 10.2	+61 23.8	-.52	11.7	15.5:	-1	DA	3	11.8:		LP106-19
444	GD546	20 25.8	+55 24	...	*	(15.5)	-1	DA	2	9.9		Hot.
445	LP25-436	20 47.9	+80 54	+.02	13.3	16.4	f-g	DA	1	11.6	4	cp dG +80°670 → $M_V \approx 12.8$.
446	GD393	20 58.9	+50 39.2	-.24	12.6	15.2	-1	DA	1	11.0	3	
447	G187-32	21 11.6	+26 09.3	-.05	13.4	14.8	0	DA	1	12.9	6	LTT16224
301	GD548	21 19.3	+58 06.7	-.04	13.3	16.0	-1	DAs	3	11.8	7	

TABLE 1 (CONT'D)

1 Gr	2 Name	3 α	 δ	4 G-R	5 M_V	6 V	7 B-V	8 Type	9 Sp.	10 H_V	11 So.	12 Remarks
448	GD395	21 32.3	+36 42.0	.07	13.4	(15.9)	0	DA-F	1	11.8		BPM96804
449	GD396	21 43.3	+35 18.3	-.66	10.7	(15.4)	-1	DA	3	12.2	3	
450	G232-38	21 48.2	+53 54.5	-.24	12.5	16.8	0	DA	1	15.3	6	
451	GD401	22 15.9	+38 53.8	-.20	12.6	16.2	-1	DF	3	13.1		W(Ca II) = 177 Å
452	GD402	22 16.8	+48 24.3	.12	13.4	16.3	-1	DC	3	12.2		
453	LP701-29	22 51.2	-07 02.6	2.3:	*	(15.7)	(3.0)	DK	1	17.8	10	stg lines; p → M_V=16.7; LHS chart.
454	LP27-275	23 01.1	+76 14	-.12	12.9	16.2	g	DC-DA,F	1	12.8	4	cp dG +75°869 → M_V = 13.0.
455	GD557	23 13.4	+68 15.0	-.22	12.7	16.2	-1	DA	1	12.0		
456	GD405	23 14.4	+47 10.8	-.57	11.5	16.4	-1	DA	1	12.3		

Footnotes to Table 1

Column 2: References to source with charts, where available; other names in column 12.

3: 1950 positions; where decimal point is not given for declination positional errors may be appreciable. Charts available on request.

4: $m_{2.12} - m_{1.85}$ from multichannel.

5: Absolute magnitude at 1/λ = 1.85 from MCSP (see Greenstein A.J., 81, 323, 1976). Uncertain M_V > 15 because of lack of calibrating parallax stars. An asterisk denotes lack of MCSP; for these M > H -3.6 if the tangential velocity is less than T = 250 km s^{-1}. H ≈ M for old disk.

6: In parentheses, m_{pg} from Luyten or Lowell proper-motion estimates or equivalent of broad-band from Basel, Beckers photometry.

7: Broad-band B-V (photoelectric or Basel equivalent) or Lowell color classes (e.g. -1,0) or Luyten colors estimates (a,f-g).

9: Sp. denotes sensors used at cassegrain focus of 5-meter reflector. 1 = multichannel, MCSP; 2 = silicon vidicon, SIT; 3 = both SIT and MCSP available; 4 = University College London Image Photon Counting System.

10: $m_V + 5 \log \mu = H_V$. If only m_{pg} is available, H_{pg} in parentheses.

Column 11:
1 - Luyten, W. J. 1949, Ap. J., 109, 528.
2 - Eggen, O. J. 1968, Ap. J. Suppl., No. 143.
3 - Wickramasinghe, D. T., Hintzen, P., Strittmatter, P. A., and Burbidge, E. M. 1975, Ap. J., 202, 191.
4 - Luyten, W. J. 1970, White Dwarfs (Univ. of Minnesota, Minneapolis).
5 - Green, R. 1977, Ph.D. Thesis, California Institute of Technology.
6 - Hintzen, P., and Strittmatter, P. A. 1974, Ap. J. (Letters), 193, L111.
7 - Various Eggen and Greenstein EG,and Greenstein degenerates, Papers I-IX.
8 - Steppe, H. in preparation, for Astr. Ap. Suppl.
9 - Dahn, C. C., and Harrington, R. S. 1976, Ap. J. (Letters), 204, L91.
10 - Dahn, C. C., Hintzen, P., Liebert, J., and Spinrad, H. 1976, Bull. AAS, 8, 506.
11 - Wegner, G. 1973, M.N.R.A.S., 163, 381.
12 - Greenstein, J. L., and Sargent, A. I. 1974, Ap. J. Suppl., No. 259.

the derived mean photometric M_V is given. When MCSP data are unavailable, M_V can be estimated from the reduced proper motion $H = m + 5 \log \mu$ (col. [10]). Other prior observers are acknowledged in column (11). In the Remarks will be found other names; possible other spectral details; if the star has a companion (cp); the tangential motion T, if large; the M_V derived from the parallax or companion. New data are given on some stars previously published (Gr or EG numbers less than 406).

The higher resolution of the SIT or IPCS often reveals that a star previously called DC may be a weak-lined hydrogen star, DAss or DAwk. Hydrogen lines persist to about 7000 K, as will be discussed elsewhere. It is now certain that EG 256 is not a degenerate but is a sdM, possibly not a physical companion of +14°2513. Composite stars (degenerate plus faint main-sequence star) often appear among stars selected by ultraviolet excess (Gr 430, 107, possibly 440). In fact, several of the Basel stars proved to be visual doubles, and were omitted. Gr 430 has a particularly interesting evolutionary history. Luyten (1970) noted it as a wide pair; the distant companion is dM2e (from the SIT), but the DA "star" is itself an unresolved double showing TiO, Ca II superposed but no emission. Why do the two dM stars have different chromospheres? The colors of AT Cnc, a nova-like variable, lead to an implausibly low luminosity if the star is assumed degenerate. On the SIT, AT Cnc has broad, shallow hydrogen absorption lines with superposed rapidly variable emission. The absorption is narrower and the emission weaker than in WZ Sge (Greenstein 1976*b*). We will discuss elsewhere in detail the spectra and luminosities of the red degenerates here listed. Further work on still fainter such stars is needed for their statistics in an unbiased sample, for the cooling theory of degenerate stars. The presently available samples seem still insufficient. Hintzen and Strittmatter (1974) noted their discovery of 21 stars with $B - V > 0.40$. That color corresponds to $G - R > 0.20$, $M_V > +13.9$; 50 stars that red now have MCSP colors, many much fainter. The frequency of stars to $\approx 10^{-4}$ $L_\odot$ might eventually be determined. However, it is not yet clear how a "complete" sample will be found.

II. COMMON-PROPER-MOTION DEGENERATES

Common-proper-motion degenerates are still rare. One of us (v.A.) has precise motions from 4 m telescope plates for LP 542–32/33 (Gr 426, 427), identical within $\pm 0''.0023$ yr^{-1} in μ_α and $\pm 0''.0035$ yr^{-1} in μ_δ. The parallaxes agree within the mean error as $+0''.0585 \pm 0''.0017$ (absolute). The MCSP visual magnitudes differ by only 0.33 mag, but $G - R$ differs by 0.25; using all measured colors, we predict a ΔM_V(ptm) of 1.0, larger than observed. The discrepancy is larger than expected for two such similar stars, and is explicable by a small difference in radius. The pair is old, not much younger than the Galaxy, since the parallax gives a tangential motion of 144 km s^{-1}. They somehow have managed to lose a considerable fraction of their initial masses, which may have been unequal and yet ended at nearly the same masses and radii.

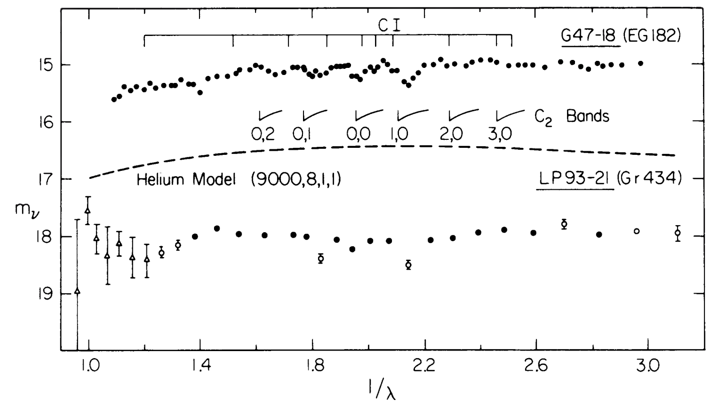

FIG. 1.—Carbon degenerates with the MCSP; EG 182 has strong C_2 and C I lines and is slightly bluer and hotter than Gr 434 (at lower spectral resolution with uncertain infrared data). *Dashed line*, flux from a 9000 K model atmosphere, interpolated between two Shipman helium models. Carbon absorption clearly distorts both stars from red to violet. Wolf 219 (EG 24, not shown) is redder and near the black-body line.

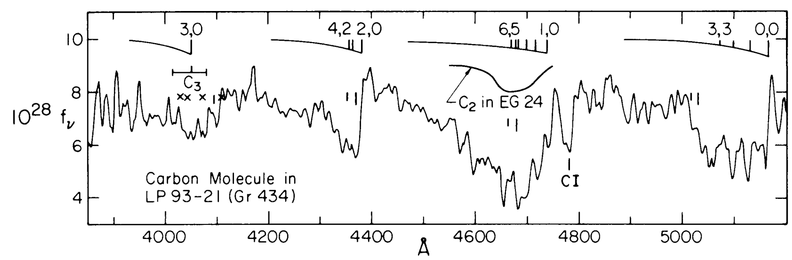

FIG. 2.—Observed SIT fluxes from Gr 434, about 3 Å resolution. The Swan band sequences $\Delta v = 0, 1, 2, 3$ are shown, with also high-pressure and other bands of C_2 (*vertical lines* and *crosses*) and the strongest C_3 feature. A possible blend of C I lines (RMT multiplet 6) is marked. In spite of the high noise level, the vibrational heads seem to be resolved. The "λ4670" band as originally observed photographically in the cooler carbon star EG 24 is sketched to scale. MCSP measures of that band make it 3 times stronger, suggesting that photographic spectra reveal only the core of a wider, stronger feature.

Most critically we require the same mean atomic weight for the stars to have cooled to so nearly the same spot in the color-magnitude diagram. The magnitudes at 1 μm, which should be near bolometric, differ by $\Delta M \approx 0.10$; this corresponds to either a 5% difference in radius (or mass) or a 2% difference in temperature, or some combination. The mass loss seems to have worked with remarkable parallelism in two stars. They are 16″ apart, corresponding to 270 AU, and should have been noninteracting during evolution. The 4″ pair LDS 275 AB (EG 66) has lower space-motion, and the stars seem to be both DC. Luyten gives a magnitude difference of 0.4 or 0.1 (1949, 1969*b*); the stars are thus also unusually similar, but require new colorimetric data. The stars in the double white dwarf G206–17/18 (Gr 373, 330) have, we are informed by Dahn (1977, unpublished), a significant, small parallax and definitely common proper motion. Their $m_{1.85}$ differ by 0.68, and their M_V from colors (Greenstein 1976*a*) are 13.45, 14.01; the parallax gives 12.78 and 13.46 ± 0.57. In this 55″ double (separation 2500 AU) the brighter is DAwk, the fainter and redder star DC. Here, too, the radii are quite similar, and progress down the cooling curves is at similar rates. Luyten (1969*b*) gives other pairs of nearly equal suspected degenerates. The wide old pairs would be interesting in study of tidal disruption of binaries containing stars with substantial mass loss.

III. A HIGH-VELOCITY CARBON DEGENERATE

The carbon star LP 93–21 (Gr 434), illustrated in Figures 1 and 2, has remarkable kinematic properties. Its proper motion is 1″.77 yr^{-1}. The distance modulus is 5.84, deduced on the assumption that is on the mean color-magnitude relations (Greenstein 1976*a*) valid for H- or He-dominated atmospheres; $M_V = 12.26 \pm 0.17$, which gives a tangential velocity $T > 1000$ km s^{-1}. The entry for Gr 434 in Table 1 must be reconsidered. The use of these relations is risky for a star with strong C_2 bands. Fortunately, a similar carbon star, G47–18 (EG 182), has a good USNO parallax, giving $M_V = 13.50 \pm 0.15$; the MCSP colors predict 12.26 ± 0.17, suggesting that a correction $\Delta M = +1.24$ be applied to our photometric luminosity of Gr 434. Gr 434 is faint, and only a low-resolution MCSP scan is available (160 Å, $\lambda < 5700$; 360 Å, $\lambda > 5700$). The scan of G47–18 (EG 182) is from Oke (1974), taken with 40/80 Å resolution: the model atmospheres, from Shipman. The Swan bands of C_2 seem stronger in Gr 434; the energy distributions make

EG 182 slightly hotter. The two carbon stars are similar, with Gr 434 cooler and fainter. Its corrected modulus is 4.25, $M_V = 13.85 \pm 0.49$, and the corrected $T = 583$ km s^{-1}. At zero radial velocity $U = +256$, $V = -524$, $W = +48$ km s^{-1}, which are just tolerable for a halo retrograde orbit, unless the radial velocity is less than -150 km s^{-1}. The Wolf 219 group (Eggen and Greenstein 1965, Table 5) had ascribed to it a number of stars of large proper motion, including several carbon degenerates, although with $T \approx 250$ km s^{-1}, only. Clearly, a parallax of LP 93–21 is of the utmost importance; if it is less than 0".028, the star is not bound to a Schmidt-model galaxy.

An interesting question is the star's radius. We have available, from Shipman, helium model atmospheres of normal metal abundance, $\log g = 8$, and $T_{\text{eff}} = 8000$ and 10,000 K. The more accurate observations of G47–18 fit the 10,000 K model fairly well, except for the regions of the strong C_2 depressions. At $10^{-2}\ R_\odot$, $M_{\text{bol}} = +12.22$ or $M_V \approx +12.8$, somewhat too bright but near the MCSP photometric value. Appreciable uncertainty arises from the back-warming effect and the bolometric correction, but EG 182 seems to have a smaller radius than the average white dwarf. The model-atmosphere fit to the relatively poor MCSP data for Gr 434 suggests $T_{\text{eff}} \gtrsim 9000$ K. At this temperature, adopting the empirical $M_V = 13.85$, $M_{\text{bol}} \approx +13.37$; at $T \geq 9000$ K this requires $R \leq 0.73 \times 10^{-2}\ R_\odot$ (or 0.59×10^{-2} at 10,000 K), which is definitely a smaller than average radius for a degenerate star, and therefore a larger than average mass. In a color-color diagram, both stars lie well above the blackbody line, indicating highly distorted spectral energy distributions.

The SIT spectrum displayed in Figure 2 shows another astrophysical feature, the broad profiles of the Swan bands. Their vibrational structure is clearly partly resolved, and the vibrational sequences, at a given Δv, go to quite high v. This is also seen in EG 182 in Figure 1, where the laboratory vibrational heads are sketched. Almost certainly both vibrational and rotational temperatures are high, which is possibly to be expected from the high density and resulting approach to collisional equilibrium. Prediction of synthetic spectra for the carbon molecule in this star may provide new information on the boundary temperature, density at the optical depth of band formation, and stability of the molecule at large vibration and rotation quantum numbers. The observations, based on only one good SIT spectrum, do not preclude the presence, as in G47–18, of the C I lines. This range of temperatures is probably just the critical one for the appearance of C I lines; the ratio of He/C is another important parameter, although both have low opacities. Hydrogen must be almost completely absent to permit such strong lines and bands.

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REFERENCES

Chavira, E. 1958, *Bol. Obs. Tonantzintla y Tacubaya*, No. 17.
Eggen, O. J., and Greenstein, J. L. 1965, *Ap. J.*, **141**, 83.
Giclas, H. L., Burnham, R. Jr., and Thomas, N. G. 1971, *Lowell Proper-Motion Survey*, and other *Lowell Obs. Bull.*
Green, R. 1977, Ph.D. thesis, California Institute of Technology.
Greenstein, J. L. 1976*a*, *A. J.*, **81**, 323.
———. 1976*b*, *Mém. Soc. Roy. Sci. Liège*, 6th Ser., **9**, 250.
Hintzen, P., and Strittmatter, P. A. 1974, *Ap. J.* (*Letters*), **193**, L111.
Iriarte, B., and Chavira, E. 1957, *Bol. Obs. Tonantzintla y Tacubaya*, No. 16.
Luyten, W. J. 1949, *Ap. J.*, **109**, 528.
———. 1963, *Proper-Motion Survey with the 48-Inch Schmidt Telescope* (Minneapolis: University of Minnesota) (LP I).
———. 1969*a*, *Proper-Motion Survey with the 48-Inch Schmidt Telescope* (Minneapolis: University of Minnesota) (LP XIX).
———. 1969*b*, *Proper-Motion Survey with the 48-Inch Schmidt Telescope* (Minneapolis: University of Minnesota) (LP XVIII).
———. 1970, *White Dwarfs* (Minneapolis: University of Minnesota).
———. 1976, *LHS Catalogue* (Minneapolis: University of Minnesota).
Oke, J. B. 1974, *Ap. J. Suppl.*, No. 236, **27**, 21.
Steinlin, U. 1968, *Zs. Ap.*, **69**, 276.
Steppe, H. 1977, *Astr. Ap. Suppl.*, in preparation.

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