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A NEW LOOK AT THE LOCAL WHITE DWARF POPULATION

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ABSTRACT

We have conducted a detailed new survey of the local population of white dwarfs lying within 20 pc of the Sun. A new revised catalog of local white dwarfs containing 122 entries (126 individual degenerate stars) is presented. This list contains 27 white dwarfs not included in a previous list from 2002, as well as new and recently published trigonometric parallaxes. In several cases new members of the local white dwarf population have come to light through accurate photometric distance estimates. In addition, a suspected new double degenerate system (WD 0423+120) has been identified. The 20 pc sample is currently estimated to be 80% complete. Using a variety of recent spectroscopic, photometric, and trigonometric distance determinations, we re-compute a space density of $4.8 \pm 0.5 \times 10^{-3}$ pc^{-3} corresponding to a mass density of $3.2 \pm 0.3 \times 10^{-3}$ $M_{\odot}$ pc^{-3} from the complete portion of the sample within 13 pc. We find an overall mean mass for the local white dwarfs of 0.665 $M_{\odot}$, a value larger than most other non-volume-limited estimates. Although the sample is small, we find no evidence of a correlation between mass and temperature in which white dwarfs below 13,000 K are systematically more massive than those above this temperature. Within 20 pc 25% of the white dwarfs are in binary systems (including double degenerate systems). Approximately 6% are double degenerates and 6.5% are Sirius-like systems. The fraction of magnetic white dwarfs in the local population is found to be 13%.

Key words: stars: distances – stars: statistics – techniques: photometric – white dwarfs

1. INTRODUCTION

The population of local white dwarfs is important because it is potentially the most complete and least-biased sample of white dwarfs available for detailed study. In particular, it offers the best statistical sample of the coolest and least luminous component of the overall white dwarf population, which is severely underrepresented in most studies. In spite of these advantages, the local population of white dwarfs remains limited and statistical inferences are subject to small sample uncertainties. Based upon rough space densities available in the literature, a count of the known white dwarfs within 20 cp of the sun is expected to result in fewer than 200 stars. For example, Holberg et al. (2002; hereafter HOS) performed such a count. This study found 109 stars and estimated that the sample at that time was 65% complete. The HOS sample has been reconsidered by several studies: Kawka et al. (2004), Schröder et al. (2004; hereafter SPN) and Kawka et al. (2007). In the course of these examinations of HOS some stars have been removed and several new stars added. In this paper we present a completely revised examination of the HOS sample that includes a significant number of new stars, preliminary parallaxes, and a much-improved estimate of photometric distances for members of the sample.

The white dwarf population has become the subject of intensive study since HOS surveyed the local population of degenerate stars within 20 pc (hereafter "the local population"). Among the notable contributions made during the last five years are the large spectroscopic studies based on the Sloan Digital Sky Survey (SDSS) of Harris et al. (2003), Kleinman et al. (2004), and Eisenstein et al. (2006) in the northern hemisphere and the SN Ia Supernova Progenitor Survey (SPY) collaboration in the southern hemisphere (Napiwotzki et al. 2001 and Koester et al. 2001). These studies have greatly expanded the number of white dwarfs of all types having detailed spectra. Additionally, SPY radial velocities have also greatly expanded our knowledge of the motions of these stars. Likewise, efforts such as The Research Consortium on Nearby Stars (RECONS; Henry et al. 1997) and new proper motion studies such as the New Luyten Two-Tenths (NLTT) proper motion survey have also broadened our knowledge of the motions of nearby white dwarf stars. These efforts, in particular those of Subasavage et al. (2007, 2008, in preparation), have yielded a number of new members of the local population. In addition to these new data, in this paper we include a number of new stars that we have determined trigonometrically or photometrically to lie within 20 pc. In contrast, new observations and re-examinations of many stars in the original HOS list have resulted in the reclassification of some entries as non-degenerate stars (Kawka et al. 2004) or revised distances that place them beyond 20 pc (SPN).

In addition to the above changes in the 20 pc sample, there now are a host of new observational data which can provide improved distance estimates and determinations of multiplicity among the stars on the original list. For example, SDSS and 2MASS (Two Micron All Sky Survey; Cutri et al. 2003) *JHK* magnitudes are now available for many nearby white dwarfs. Moreover, spectroscopic data are now available for almost all stars in the sample. This not only lends improved confidence to the degenerate identity of sample members but also provides improved estimates of properties such as temperature, gravity, atmospheric composition, and mass. Given these advances it is now appropriate to revisit the local population of white dwarfs. In HOS reliance was placed on color–magnitude relations to estimate photometric distances for many stars. Using new precise photometric methods (Holberg et al. 2008, hereafter HBG) greatly improved photometric distances for DA and other H-rich white dwarfs are now possible. In pursuing this objective we have identified several new DA stars which lie within 20 pc. Likewise, we have modified the determinations of distance-related quantities, such as space density, mass density and even sample membership to include the distance uncertainty. In this way we can make use of the probability that a star lies at a particular distance rather than a simple distance-based star count. This is particularly important at sample boundaries such as 13 pc and 20 pc.

In Section 2 we introduce the local sample of white dwarfs, listing trigonometric parallaxes where available. We also provide the physical parameters of these stars, including effective temperatures, gravities and masses. Finally, we provide trigonometric and photometric distances for the stars in the local sample and describe our methods for estimating photometric distances. In Section 3 we augment the local sample with a list of white dwarfs that have a substantial probability of lying within 20 pc and warrant more precise observations. In Section 4 we determine the static spatial properties of the local white dwarf population, including stellar space and mass density of these stars as well as a census of different white dwarf spectral types in this volume of space. Finally, in Section 5 we compare our results to other recent surveys of the local white dwarf population and discuss the outlook for additional studies of this population. The Appendix is a list of stars removed from the previous HOS study of the local white dwarf population.

2. THE LOCAL SAMPLE

Table 1 contains 122 entries corresponding to all of the spectroscopically identified white dwarfs within 20 pc that are known to us. The total number of individual degenerate stars, counting both members of four unresolved double degenerate systems, is 126 stars. In Table 1 the 122 entries are listed by WD number and a common alternate designation. The degenerate spectral type, as defined by the revised system of McCook & Sion (1999), together with our best determination of the visual magnitude (based on a consensus of published values) is provided along with information on any known companions. Trigonometric parallaxes and uncertainties are given, where available, along with the published source of the parallax. If no parallax is listed, a reference is provided for the determination that the star lies within 20 pc. The 126 degenerates contained in Table 1 represent a significant increase over the 109 listed in HOS, the 102 listed in SPN, and the 116 considered by Kawka et al. (2007). In order to track the changes between HOS and the list in Table 1, we have annotated the 27 new entries and in the Appendix we provide a list of the 12 deleted stars (Table A1).

Several good photometry-based sources of new (see Table 1) and potentially new (see Section 3) local white dwarfs exist. These include Farihi et al. (2005), Kawka & Vennes (2006), Kawka et al. (2007), and Subasavage et al. (2007, 2008, in preparation). Many new members of the local population are drawn from these sources. However, wherever possible we have made an independent determination of the photometric distance (and uncertainty) based on multi-band photometry and the methods described in HBG. In addition to these published sources we have found two additional DA stars (WD 1124+595 and WD 1632+177) whose photometric data indicate that they lie within 20 pc.

2.1. Trigonometric Parallaxes

In Table 1, 26 entries presently lack published parallaxes. However, many of these 26 stars are part of several ongoing parallax programs. Indeed, 15 of these stars (flagged in Table 1) have preliminary parallaxes that indicate that they lie within 20 pc, to a high degree of confidence. Thus, in the not too distant future virtually all of the local sample will have trigonometric parallaxes. Although the parallaxes for most stars in Table 1 are still derived from the Yale catalog (Van Altena et al. 1994) and the *Hipparco*s catalog (Perryman 1997), there have been some notable additions. Smart et al. (2003) determined parallaxes for WD 0322−019 and WD 0423+120 and Ducourant et al. (2007) provided a parallax for WD 2211−392. In addition, several new parallaxes are available from the RECONS program: WD 0121−429 and WD 2008−600 (Subasavage et al. 2007) and WD 0552−041 and WD 0738−172 (Costa et al. 2005). New preliminary parallaxes are contained in Subasavage et al. (2008, in preparation).

2.2. Temperatures, Gravities, and Masses

Table 2 lists the effective temperatures ($T_{\rm eff}$), surface gravities (log g) and masses, along with the corresponding uncertainties, for each star in our sample. These parameters are taken from a variety of sources in the published literature, which are referenced in Table 2. Because of the wide range of temperatures and spectral types, a mixture of spectroscopic and photometric data have been used in estimating the astrophysical properties listed in Table 2. For some of the warmer DA and DAZ stars as well as some DQ and DZ stars spectroscopically derived temperatures and gravities are used. Particularly for cooler white dwarfs and non-DA stars, the effective temperatures and gravities are deduced primarily from photometric data and/or taken from the literature. The spectral type designations given in Table 1 are consistent with our adopted $T_{\rm eff}$ values.

Bergeron et al. (2001; BLR), Liebert et al. (2005; LBH), and Bergeron et al. (2007; BGB) noted that spectroscopic gravities obtained for DA stars with temperatures below 12,000–13,000 K seem to systematically overestimate the actual surface gravities and the corresponding masses of these stars. The origin of this effect is thought to be due to the onset of convection, resulting in the mixing of spectroscopically undetectable He into the H-rich photospheres. One approach to mitigating this effect is to make use of trigonometric parallaxes to determine gravities and masses using the mass–radius relation. BLR employed this method on a large sample of white dwarfs. Approximately one half of the stars in our local sample are in BLR and we have preferentially used their results in Table 2 (Ref. 1). Likewise, we have relied on the results of Dufour et al. (2005, Ref. 11) and (2007, Ref. 10) for most of our DQ and DZ stars, which also employ trigonometric parallaxes.

Where no spectroscopic data exist, we have relied on photometric data. Principal among these cases are stars observed by Subasavage et al. (2007, Ref. 13). It is has been noted that for cool DAs where spectroscopy is suspect, estimates of temperature and gravity based on photometry alone do not seem to show any systematic increase in gravity and mass (Engelbrecht & Koester 2007). Finally, Table 2 also lists the dominant photospheric composition, either H-rich or He-rich. These determinations are for the most part taken from the references given in the table.

Table 1
The Local Sample of White Dwarfs

WD No.	Alt. ID	Type	V	π (mas)	σ_π (mas)	Ref.	System[d]
WD 0000−345	LHS 1008	DC8.1	14.96	75.70	9.00	1	
WD 0008+423[a,c]	NLTT 529	DA6.8	15.23	...	...	4	
WD 0009+501	LHS 1038	DAH7.6	14.360	90.60	3.70	1	
WD 0011−134	LHS 1044	DCH8.4	15.87	51.30	3.80	1	
WD 0038−226	LHS 1126	DQ9.3	14.52	101.20	10.40	1	
WD 0046+051	V Ma 2	DZ8.1	12.39	231.63	1.74	1, 2	
WD 0108+277[a,c]	NLTT 3915	DAZ9.6	16.15	...	...	4	
WD 0115+159	LHS 1227	DQ5.6	13.84	64.90	3.00	1	
WD 0121−429[a,b,c]	LHS 1243	DAH7.9	14.83	56.6	2.2	7	dd?
WD 0135−052	LHS 1270	DA6.9	12.84	81.00	2.80	1	dd
WD 0141−675[b]	LHS 145	DA7.8	13.82	...	...	7	
WD 0148+467	GD 279	DA3.8	12.44	63.08	3.39	2	b
WD 0148+641	G244–36	DA5.6	13.99	...	...	9	b
WD 0208+396	LHS 151	DAZ6.9	14.526	59.80	3.5	1	
WD 0213+427	LHS 153	DA9	16.210	50.20	4.1	1	
WD 0230−144	LHS 1415	DC9.2	15.77	64.00	3.9	1	
WD 0233−242[c]	NLTT 8435	DC9.3	15.75	...	...	4	
WD 0245+541	LHS 1446	DAZ9.5	15.34	96.60	3.1	1	
WD 0310−688	LB 3303	DA3.3	11.37	98.50	1.24	2	
WD 0322−019	LHS 1547	DAZ9.7	16.22	59.50	3.2	3	dd
WD 0326−273	LHS 1549	DA5.4	13.77	57.60	13.6	1	dd
WD 0341+182	LHS 179	DQ7.7	15.19	52.60	3.0	1	
WD 0344+014[a,c]	LHS 5084	DC9.9	16.52	...	...	7	
WD 0357+081	LHS 1617	DC9.2	15.887	56.10	3.7	1	
WD 0413−077	40 Eri B	DAP3.1	9.521	198.24	0.67	2	b
WD 0423+120	LB 1320	DA8.2	15.42	57.60	2.5	3	
WD 0426+588	LHS 27	DC7.1	12.432	180.73	0.78	1, 2	b
WD 0433+270	G39–27	DA9	15.824	56.02	1.09	2	b
WD 0435−088	LHS 194	DQ8.0	13.781	105.20	2.6	1	
WD 0457−004[a,c]	NLTT 14307	DA4.7	15.30	...	...	4	
WD 0548−001	G99–037	DQP8.3	14.58	90.30	2.8	1	
WD 0552−041	LHS 32	DZ11.8	14.488	155.00	2.1	1	
WD 0553+053	LHS 212	DAP8.7	14.105	125.10	3.6	1	
WD 0642−166	Sirius B	DA2	8.44	379.83	1.05	1, 2	b
WD 0644+025	G108–26	DA6.9	15.695	54.20	5.5	1	
WD 0644+375	EG 50, LHS 1870	DA2.4	12.082	64.91	2.93	2	
WD 0657+320	LHS 1889	DC10.1	16.593	65.83	1.7	1	
WD 0659−063	LHS 1892	DA7.7	15.425	81.00	24.2	1	
WD 0727+482.1	LHS 230A	DA10.0	15.26	90.00	10	1	dd
WD 0727+482.2	LHS 230B	DA10	15.56	90.00	10	1	
WD 0728+642	G234–004	DAP11.2	16.38	...	...	9	
WD 0736+053	Procyon B	DQZ6.5	10.92	285.93	0.82	2	b
WD 0738−172	LHS 235	DAZ6.6	13.02	107.76	1.62	1, 8	b
WD 0743−336	VB03	DC10.6	16.595	65.79	0.40	2	b
WD 0747+073.1	LHS 239	DC12.1	16.99	54.70	0.7	1	dd
WD 0747+073.2	LHS 240	DC11.9	16.69	54.70	0.7	1	
WD 0749+426[a,c]	NLTT 18555	DC11.7	17.45	...	...	4	
WD 0751−252[a,b,c]	SCR 0753–2524	DA10.0	16.270	51.16	1.57	2	b
WD 0752−676	LHS 34	DC8.8	14.012	141.20	8.4	1	
WD 0806−661[c]	BPM 4834	DQ4.2	13.73	...	...	7	
WD 0821−668[b,c]	SCR 0821–6703	DA9.8	15.34	...	...	11	
WD 0839−327	LHS 253	DA5.4	11.870	112.70	9.7	1	
WD 0840−136[a,c]	NLTT 20107	DZ10.3	15.72	...	...	7	
WD 0912+536	LHS 262	DCP7	13.88	97.00	1.9	1	
WD 0955+247[c]	PG, G49–33	DA5.8	15.08	40.9	4.5	1	
WD 1009−184[a,b,c]	WT 1759	DZ7.8	15.44	58.59	1.66	2	b
WD 1019+637	G235–67	DA7.2	14.71	61.20	3.6	1	
WD 1033+714	LHS 285	DC10.3	16.89	...	...	6	
WD 1036−204[b]	LHS 2293	DQP6.5	16.24	...	...	7	
WD 1043−188	LHS 290	DQ8.1	15.51	56.9	6.5	1	b
WD 1055−072	LHS 2333	DA6.8	14.32	82.3	3.5	1	
WD 1121+216	LHS 304	DA6.7	14.240	74.5	2.8	1	
WD 1124+595[a,c]	GD 309	DA4.8	15.20	...	...	9	
WD 1132−325	VB 4, LHS 309	DC?	15.00	104.84	0.81	2	b

Table 1
(Continued)

WD No.	Alt. ID	Type	V	π (mas)	σ_π (mas)	Ref.	System[d]
WD 1134+300	GD 140	DA2.4	12.48	65.28	2.67	2	
WD 1142−645	LHS 43	DQ6.4	11.50	216.51	1.57	1, 2	b
WD 1202−232[b,c]	NLTT 29555	DAZ5.7	12.80	...	...	7	
WD 1223−659[b]	L104–2	DA6.5	13.97	50	...	7	
WD 1236−495	LHS 2594	DA4.3	13.767	61.00	9.4	1	
WD 1257+037	LHS 2661	DA9	15.83	60.30	3.8	1	
WD 1309+853	G256–7	DAP9	15.99	55.40	...	9	
WD 1310−472	ER8	DC11.9	17.08	66.50	2.4	1	
WD 1327−083	LHS 354	DA3.6	12.327	59.29	2.15	1, 2	b
WD 1334+039	LHS 46	DZ10.0	14.66	121.40	3.4	1	
WD 1344+106	LHS 2800	DAZ7.1	15.11	49.90	3.6	1	
WD 1345+238	LHS 361	DA11	15.65	82.90	2.2	1	b
WD 1444−174	LHS 378	DC10.2	16.46	69.00	4.0	1	
WD 1544−377	L481–60	DA4.8	12.78	65.60	0.64	2	b
WD 1609+135	LHS 3163	DA5.4	15.103	54.50	4.7	1	
WD 1620−391	CD-38° 10980	DA2.1	10.977	77.73	0.31	2	b
WD 1626+368	LHS 3200	DZ6.0	13.834	62.70	2.0	1	
WD 1632+177 [c]	PG 1632+177	DA5	13.106	...	...	9	
WD 1633+433	G180–063	DAZ7.7	14.834	66.20	3.0	1	b
WD 1633+572	LHS 422	DQ8.2	15.004	69.20	2.5	1	
WD 1647+591	G226–29	DAV4.1	12.21	91.13	2.23	2	
WD 1653+385[c]	NLTT 43806	DAZ8.8	15.86	...	...	4	
WD 1655+215[c]	PG, LHS 3254	DA5.4	14.09	43.0	3.1	1	
WD 1705+030	G139–13	DZ7.7	15.194	57.00	5.4	1	
WD 1748+708	LHS 455	DQP9.0	14.15	164.70	2.4	1	
WD 1756+827	LHS 56	DA6.9	14.309	63.90	2.9	1	
WD 1814+134[a,b,c]	LSR 1817+1328	DA9.5	15.85	...	...	7	
WD 1820+609	G227–28	DA10.5	15.67	78.20	4.1	1	
WD 1829+547	G227–35	DQP8	15.535	66.80	5.6	1	
WD 1900+705	LHS 3424	DAP4.2	13.23	77.00	2.3	1	
WD 1917+386	G125–3	DC7.9	14.59	85.50	3.4	1	
WD 1917−077	LDS 678A	DBQA4.9	12.30	99.20	2.5	1	b
WD 1919+145	GD 219	DA3.5	13.00	50.50	5.5	1	
WD 1935+276	G185–32	DA4.2	12.987	55.70	2.9	1	
WD 1953−011	LHS 3501	DAP6.5	13.698	87.80	2.9	1	
WD 2002−110	LHS 483	DA10.5	16.90	57.70	0.8	1	
WD 2007−303	LTT 7987	DA3.5	12.18	65.06	3.39	2	
WD 2008−600[b,c]	SCR 2012–5956	DC9.9	15.84	58.48	1.4	8	
WD 2032+248	LHS 3562	DA2.5	11.523	68.22	1.35	1, 2	
WD 2047+372	G210–36	DA3.6	12.97	...	...	9	
WD 2048+263	LHS 3589	DA9.7	15.607	49.80	3.4	1	b
WD 2054−050	LHS 3601	DC10.9	16.68	58.61	2.51	1, 2	b
WD 2105−820	L24–52	DAP4.8	13.601	58.60	8.8	1	
WD 2117+539	G231–40	DA3.6	12.348	50.70	7.4	1	
WD 2138−332[a,b,c]	L570–26	DZ7	14.47	...	...	7	
WD 2140+207	LHS 3703	DQ6.1	13.253	79.90	3.2	1	
WD 2154−512	LTT 8768	DQ7	14.74	61.13	2.67	1	b
WD 2159−754[c]	LHS 3752	DA5.6	15.03	...	...	5	
WD 2211−392[c]	WD 2214–390	DA8	15.92	53.2	2.2	10	
WD 2226−754[b,c]	SPMJ2231–7514	DC11.9	16.57	...	...	7	
WD 2226−755[b,c]	SPMJ2231–7515	DC12.1	16.88	...	...	7	dd
WD 2246+223	LHS 3857	DA4.7	14.36	52.50	4.1	1	
WD 2251−070	LHS 69	DZ112.6	15.665	123.70	4.3	1	
WD 2322+137[c]	NLTT 56805	DA10.7	15.81	...	...	4	
WD 2326+049	G29–38	DAZ4.4	13.05	73.40	4.0	1	
WD 2336−079[b]	GD 1212	DAZ4.6	13.26	...	...	9	
WD 2341+322[b]	G130–5	DA4.0	12.932	56.80	1.8	1	b
WD 2359−434	LHS 1005	DAP5.9	12.76	127.4	6.8	1	

Notes.
[a] Not presently in the Villanova Catalog.
[b] Preliminary trigonometric parallax indicates star well within 20 pc.
[c] New entery (not in HOS).
[d] b = Binary or multiple system, dd = double-degenerate system.

References. (1) Van Altena et al. (1994); (2) Perryman (1997); (3) Smart et al. (2003); (4) Kawka & Vennes (2006); (5), Kawka et al. (2007); (6), Kawka et al. (2004); (7) Subasavage et al. (2007); (8) Costa et al. (2005); (9) photometric estimate; (10) Ducourant et al. (2007); (11) Subasavage et al. (2008, in preparation).

Table 2
Local Sample: Physical Parameters

WD	Comp.	T_{eff}	σT	log g	($\log g$	Mass	unc	Ref.
WD 0000−345	He	6240	140	8.31	0.16	0.77	0.01	1
WD 0008+423	H	7380	60	8.38	0.08	0.84	0.05	8
WD 0009+501	H	6610	79	8.36	0.038	0.82	0.02	3
WD 0011−134	H	6010	120	8.20	0.11	0.72	0.07	1
WD 0038−226	He	5400	170	7.91	0.17	0.63	. . .	1
WD 0046+051	He	6220	240	8.19	0.04	0.69	0.02	10
WD 0108+277	H	5270	250	8.36	0.60	0.82	0.39	8
WD 0115+159	He	9050	310	8.19	0.07	0.69	0.04	11
WD 0121−429	H	6369	137	. . .	. . .	0.59	0.17	13
WD 0135−052	H	7280	87	7.85	0.038	0.52	0.02	3
WD 0141−675	H	6460	160	8.04	0.44	0.62	0.29	9
WD 0148+467	H	13430	161	7.93	0.038	0.58	0.02	3
WD 0148+641	H	8938	19	8.354	0.023	0.82	0.01	15
WD 0208+396	H	7340	33	8.10	0.057	0.66	0.04	14
WD 0213+427	H	5600	160	8.12	0.12	0.66	0.08	1
WD 0230−144	H	5480	120	8.11	0.09	0.65	0.06	1
WD 0233−242	He	5400	500	8.0	. . .	0.58	. . .	5
WD 0245+541	H	5280	120	8.28	0.05	0.76	0.03	1
WD 0310−688	H	15500	79	8.027	0.014	0.63	0.01	14
WD 0322−019	H	5220	110	7.50	. . .	0.33	. . .	2
WD 0326−273	H	9250	111	7.86	0.038	0.53	0.02	3
WD 0341+182	He	6510	130	7.99	0.10	0.57	0.06	11
WD 0344+014	He	5084	91	. . .	. . .	0.58	0.17	13
WD 0357+081	H	5490	130	8.02	0.11	0.60	0.07	1
WD 0413−077	H	16176	76	7.865	0.015	0.497	0.005	14
WD 0423+120	He	6150	130	8	. . .	0.59	0.17	2
WD 0426+588	He	7120	180	8.17	0.01	0.68	0.01	1
WD 0433+270	H	5620	110	8.14	0.07	0.67	0.05	1
WD 0435−088	He	6300	110	7.93	0.04	0.53	0.02	11
WD 0457−004	H	10800	80	9.15	0.06	1.25	0.02	8
WD 0548−001	He	6070	100	8.18	0.04	0.69	0.03	11
WD 0552−041	He	4270	70	7.80	0.02	0.45	0.01	10
WD 0553+053	H	5790	110	8.20	0.05	0.71	0.03	1
WD 0642−166	H	25193	37	8.556	0.01	1.00	0.01	7
WD 0644+025	H	7410	180	8.66	0.12	1.01	0.07	1
WD 0644+375	H	21060	138	8.1	0.03	0.69	0.02	5
WD 0657+320	H	4990	130	8.07	0.03	0.62	0.02	1
WD 0659−063	H	6520	150	8.71	0.36	1.04	0.22	1
WD 0727+482.1	H	5020	120	7.92	0.02	0.53	0.01	1
WD 0727+482.2	H	5060	130	8.12	0.02	0.66	0.01	1
WD 0728+642	H	4500	500	. . .	. . .	0.58	0.18	25
WD 0736+053	He	7740	50	. . .	. . .	0.602	0.015	19
WD 0738−172	He	7590	220	8.07	0.03	0.62	0.02	10
WD 0743−336	He	4740	50	7.97	0.09	0.56	0.05	1
WD 0747+073.1	He	4850	50	8.04	0.02	0.61	0.01	1
WD 0747+073.2	H	5000	130	8.12	0.02	0.40	0.01	1
WD 0749+426	H	4300	300	8.0	. . .	0.58	0.18	8
WD 0751−252	H	5159	107	. . .	. . .	0.58	0.17	12
WD 0752−676	H	5730	110	8.21	0.09	0.72	0.06	1
WD 0806−661	He	11940	550	8	. . .	0.62	. . .	11
WD 0821−668	H	5160	95	. . .	. . .	0.58	0.17	13
WD 0839−327	H	9268	28	7.885	0.039	0.54	0.02	14
WD 0840−136	He	4900	100	. . .	. . .	0.63	. . .	13
WD 0912+536	He	7160	190	8.28	0.03	0.75	0.02	1
WD 0955+247	H	8621	33	8.301	0.019	0.79	0.01	14
WD 1009−184	He	6449	194	. . .	. . .	0.59	0.17	13
WD 1019+637	H	6981	48	8.253	0.19	0.76	0.12	14
WD 1033+714	He	4888	80	8	. . .	0.57	0.18	20
WD 1036−204	He	4948	70	8	. . .	0.58	0.17	13
WD 1043−188	He	6190	200	8.09	0.17	0.63	0.11	1
WD 1055−072	He	7420	200	8.42	0.06	0.85	0.04	1
WD 1121+216	H	7471	38	8.197	0.066	0.72	0.04	14
WD 1124+595	H	10,500	200	. . .	. . .	0.6	0.17	21
WD 1132−325	. . .	. . .	. . .	. . .	. . .	. . .	. . .	22

Table 2
(Continued)

WD	Comp.	T_{eff}	σT	log g	($\log g$	Mass	unc	Ref.
WD 1134+300	H	21276	126	8.545	0.018	0.96	0.01	14
WD 1142−645	H	7900	220	8.07	0.02	0.62	0.01	11
WD 1202−232	H	8774	9	8.10	0.02	0.66	0.01	17
WD 1223−659	H	7740	70	8.13	0.11	0.68	0.07	9
WD 1236−495	H	11748	51	8.802	0.017	1.09	0.01	14
WD 1257+037	H	5595	110	8.16	0.016	0.69	0.01	14
WD 1309+853	H	5600	...	...	...	0.58	0.17	26
WD 1310−472	H	4220	80	8.12	0.05	0.65	0.04	1
WD 1327−083	H	13920	167	7.86	0.038	0.54	0.02	3
WD 1334+039	He	5030	120	7.95	0.02	0.55	0.03	14
WD 1344+106	H	7135	40	8.119	0.022	0.67	0.01	14
WD 1345+238	H	4590	150	7.76	0.05	0.44	0.02	1
WD 1444−174	He	4960	60	8.37	0.08	0.81	0.05	1
WD 1544−377	H	10538	127	8.09	0.038	0.66	0.02	3
WD 1609+135	H	9321	22	8.644	0.024	1.01	0.06	14
WD 1620−391	H	24276	100	8.011	0.015	0.64	0.01	14
WD 1626+368	He	8440	320	8.02	0.05	0.59	0.03	10
WD 1632+177	H	10100	14	7.956	0.014	0.58	0.7	24
WD 1633+433	H	6518	64	7.735	0.144	0.46	0.07	14
WD 1633+572	He	6180	240	8.09	0.06	0.63	0.03	1
WD 1647+591	H	12260	147	8.31	0.038	0.80	0.02	3
WD 1653+385	H	5700	240	8.28	0.50	0.77	0.33	8
WD 1655+215	H	9313	24	8.203	0.028	0.73	0.02	14
WD 1705+030	He	6580	200	8.20	0.17	0.70	0.09	10
WD 1748+708	He	5590	90	8.36	0.02	0.81	0.01	1
WD 1756+827	H	7270	330	7.98	0.07	0.58	0.03	1
WD 1814+134	H	5313	115	...	...	0.58	0.17	13
WD 1820+609	H	4780	140	7.83	0.09	0.48	0.05	1
WD 1829+547	H	6280	140	8.5	0.11	0.90	0.07	1
WD 1900+705	H?	12070	990	8.58	0.03	0.95	0.02	9
WD 1917+386	He	6390	140	8.28	0.05	0.75	0.04	1
WD 1917−077	He	10200	1000	...	...	0.55	...	23
WD 1919+145	H	15108	12	8.078	0.001	0.66	0.01	18
WD 1935+276	H	12130	195	8.05	0.043	0.64	0.03	6
WD 1953−011	H	7920	200	8.23	0.05	0.74	0.03	1
WD 2002−110	He	4800	50	8.31	0.02	0.77	0.01	1
WD 2007−303	H	14454	97	7.857	0.017	0.54	0.01	14
WD 2008−600	He	5078	221	...	...	0.58	0.17	13
WD 2032+248	H	19980	104	7.83	0.028	0.55	0.01	5
WD 2047+372	H	14070	169	8.21	0.038	0.74	0.02	3
WD 2048+263	H	5200	110	7.31	0.12	0.26	0.04	1
WD 2054−050	He	4620	40	8.09	0.12	0.62	0.08	1
WD 2105−820	H	10559	39	8.184	0.029	0.72	0.02	14
WD 2117+539	H	13990	168	7.78	0.038	0.51	0.02	3
WD 2138−332	He	7188	291	...	...	0.63	...	13
WD 2140+207	He	8200	250	7.84	0.06	0.49	0.04	11
WD 2154−512	He	...	...	...	...	0.63	...	...
WD 2159−754	H	9040	80	8.95	0.12	1.17	0.07	9
WD 2211−392	H	6290	100	8	...	0.59	0.18	16
WD 2226−754	H	4230	104	...	...	0.58	0.18	13
WD 2226−755	H	4177	112	...	...	0.58	0.18	13
WD 2246+223	H	10647	30	8.803	0.02	1.09	0.01	14
WD 2251−070	He	4000	200	8.01	0.06	0.58	0.04	10
WD 2322+137	H	4700	300	7.0	...	0.18	...	8
WD 2326+049	H	11562	24	8.008	...	0.61	0.02	18
WD 2336−079	H	11040	132	8.11	0.038	0.67	0.02	4
WD 2341+322	H	12570	151	7.93	0.038	0.57	0.02	3
WD 2359−434	H	8570	50	8.6	0.06	0.97	0.03	9

References. (1) BLR; (2) Bergeron et al. (1997); (3) Gianninas et al. (2005); (4) Gianninas et al. (2006); (5), Bergeron et al. (1992); (6) Bergeron et al. (2004); (7) Barstow et al. (2005); (8) Kawka & Vennes (2006); (9) Kawka et al. (2007); (10) Dufour et al. (2007); (11) Dufour et al. (2005); (12) Subasavage et al. (2008, in preparation); (13) Subasavage et al. (2007); (14) HBG; (15) P. Bergeron & A. Gianninas (2007, private communication); (16) Bergeron et al. (2005); (17) Koester et al. (2001); (18) Voss (2006); (19) Provencal et al. (2002); (20) LRB; (21), Eisenstein et al. (2006); (22) Henry et al. (2002); (23) Oswalt et al. (1991); (24) Putney (1997); (25) Putney (1995).

Table 3
Local Sample: Distances

WD	$d_{\text{trig.}}$ (pc)	σ (pc)	d_{phot} (pc)	σ (pc)	Adapted (pc)	σ (pc)	Notes
WD 0000−345	13.21	1.57	12.08	1.55	12.65	1.10	a
WD 0008+423	...	...	17.88	1.09	17.88	1.09	
WD 0009+501	11.04	0.45	9.93	0.44	11.04	0.45	
WD 0011−134	19.49	1.44	18.46	2.44	19.49	1.44	
WD 0038−226	9.88	1.02	9.37	1.20	9.88	1.02	
WD 0046+051	4.32	0.03	4.06	0.23	4.32	0.03	
WD 0108+277	...	...	13.79	6.01	13.79	6.01	
WD 0115+159	15.41	0.71	15.57	8.12	15.41	0.71	
WD 0121−429	17.67	0.69	...	...	17.67	0.69	
WD 0135−052	12.35	0.43	8.35	0.31	12.35	0.43	
WD 0141−675	...	...	9.70	0.20	9.70	0.20	
WD 0148+467	15.85	0.85	16.27	0.52	16.06	0.44	a
WD 0148+641			17.13	3.95	17.13	3.95	
WD 0208+396	16.72	0.98	15.54	0.34	16.13	0.32	a
WD 0213+427	19.92	1.63	19.42	2.08	19.67	1.28	a
WD 0230−144	15.63	0.95	15.14	1.26	15.39	0.76	a
WD 0233−242	...	...	15.67	4.68	15.67	4.68	
WD 0245+541	10.35	0.33	10.57	0.79	10.35	0.33	
WD 0310−688	10.15	0.13	10.46	0.14	10.15	0.13	
WD 0322−019	16.81	0.90	23.90	6.78	16.81	0.90	
WD 0326−273	17.36	4.10	19.73	0.83	19.73	0.83	
WD 0341+182	19.01	1.08	18.33	1.31	19.01	1.08	
WD 0344+014	...	...	19.90	3.10	19.90	3.10	
WD 0357+081	17.83	1.18	17.08	1.58	17.46	0.95	a
WD 0413−077	5.04	0.02	5.18	0.07	5.04	0.02	
WD 0423+120	17.36	0.75	11.88	2.36	17.36	0.75	
WD 0426+588	5.53	0.02	5.37	0.26	5.53	0.02	
WD 0433+270	17.85	0.35	16.08	1.16	17.85	0.35	
WD 0435−088	9.51	0.23	9.29	0.42	9.51	0.23	
WD 0457−004	...	...	17.67	1.15	17.67	1.15	
WD 0548−001	11.07	0.34	12.45	0.55	11.07	0.34	
WD 0552−041	6.45	0.09	6.01	0.26	6.45	0.09	
WD 0553+053	7.99	0.23	7.50	0.42	7.99	0.23	
WD 0642−166	2.63	0.01	2.73	0.04	2.63	0.01	
WD 0644+025	18.45	0.87	17.20	1.97	17.83	0.80	a
WD 0644+375	15.41	0.70	18.42	0.28	15.41	0.70	
WD 0657+320	15.19	0.39	18.04	1.28	15.19	0.39	
WD 0659−063	12.35	3.69	11.91	3.79	12.13	2.64	a
WD 0727+482.1	11.11	1.23	10.90	0.69	11.01	0.60	a
WD 0727+482.2	11.11	1.23	11.23	0.76	11.20	0.65	
WD 0728+642	...	...	13.4	4.2	13.4	4.2	
WD 0736+053	3.50	0.01	3.52	0.71	3.50	0.01	
WD 0738−172	9.28	0.14	10.19	2.36	9.28	0.14	
WD 0743−336	15.20	0.09	...	...	15.20	0.09	
WD 0747+073.1	18.28	0.23	17.97	0.75	18.25	0.22	a
WD 0747+073.2	18.28	0.23	15.62	0.74	18.25	0.22	
WD 0749+426	...	...	19.74	4.60	19.74	4.60	
WD 0751−252	19.55	0.60	15.80	2.10	19.55	0.60	
WD 0752−676	7.08	0.42	6.98	0.60	7.05	0.34	a
WD 0806−661	...	...	21.1	3.5	19.08	0.58	
WD 0821−668	...	...	11.5	1.9	11.5	1.9	
WD 0839−327	8.87	0.76	8.05	0.11	8.07	0.11	a
WD 0840−136	...	...	19.3	3.9	19.3	3.9	
WD 0912+536	10.31	0.20	11.59	2.28	10.31	0.20	
WD 0955+247	24.45	2.69	18.83	0.39	18.95	0.39	a
WD 1009−184	17.07	0.48	20.90	3.50	17.07	0.48	
WD 1019+637	...	...	13.93	0.40	13.93	0.40	
WD 1033+714	...	...	20.00	3.20	20.00	3.20	
WD 1036−204	...	...	16.2	2.5	16.2	2.5	
WD 1043−188	17.57	2.01	17.88	2.46	17.57	2.01	
WD 1055−072	12.15	0.52	11.54	0.77	11.96	0.43	a
WD 1121+216	13.42	0.50	13.60	0.33	13.55	0.28	a
WD 1124+595	...	...	17.90	...	17.90	...	
WD 1132−325	9.54	0.07	...	...	9.54	0.07	
WD 1134+300	15.32	0.63	15.38	0.25	15.37	0.23	a
WD 1142−645	4.62	0.03	4.46	0.31	4.62	0.03	

Table 3
(Continued)

WD	$d_{\text{trig.}}$ (pc)	σ (pc)	d_{phot} (pc)	σ (pc)	Adapted (pc)	σ (pc)	Notes
WD 1202−232	...	...	10.2	1.7	10.2	1.7	
WD 1223−659	...	...	12.05	1.31	12.05	1.31	
WD 1236−495	16.39	2.53	13.69	0.22	13.71	0.22	a
WD 1257+037	16.58	1.05	16.07	0.55	16.18	0.49	a
WD 1309+853	18.05	...	19.03	5.34	18.05	...	
WD 1310−472	15.04	0.54	14.76	0.79	14.95	0.45	a
WD 1327−083	16.87	0.61	16.36	0.32	16.47	0.28	a
WD 1344+039	8.24	0.23	8.20	0.23	8.24	0.23	
WD 1334+106	20.04	1.45	19.44	0.48	19.50	0.46	a
WD 1345+238	12.06	0.32	12.71	0.43	12.06	0.32	
WD 1444−174	14.49	0.84	13.61	0.87	14.07	0.60	a
WD 1544−377	15.24	0.15	13.16	0.41	14.99	0.14	
WD 1609+135	18.35	1.58	20.29	0.36	18.35	1.58	
WD 1620−391	12.87	0.05	13.03	0.18	12.87	0.05	
WD 1626+368	15.95	0.51	16.97	1.12	15.95	0.51	
WD 1632+177	...	...	15.99	0.20	15.99	0.20	
WD 1633+433	15.11	0.68	18.28	0.74	15.11	0.68	
WD 1633+572	14.45	0.52	18.33	0.73	14.45	0.52	
WD 1647+591	10.97	0.27	10.48	0.35	10.79	0.21	a
WD 1653+385	...	...	15.35	5.61	15.35	5.61	
WD 1655+215	23.26	1.68	18.47	0.31	18.63	0.30	a
WD 1705+030	17.54	1.66	16.55	1.71	17.06	1.19	a
WD 1748+708	6.07	0.09	6.32	0.25	6.07	0.09	
WD 1756+827	15.65	0.71	15.13	1.45	15.55	0.64	a
WD 1814+134	15.00	...	15.6	2.5	15.6	2.5	
WD 1820+609	12.79	0.67	12.22	1.11	12.79	0.67	
WD 1829+547	14.97	1.25	13.95	1.38	14.97	1.25	
WD 1900+705	12.99	0.39	13.38	1.22	12.99	0.39	
WD 1917+386	11.70	0.47	10.91	0.67	11.70	0.47	
WD 1917−077	10.08	0.25	10.82	2.83	10.08	0.25	
WD 1919+145	19.80	2.16	20.30	1.64	19.80	2.16	
WD 1935+276	17.95	0.93	18.03	0.73	18.00	0.57	a
WD 1953−011	11.39	0.38	11.16	0.66	11.39	0.38	
WD 2002−110	17.33	0.24	16.00	0.57	17.33	0.24	
WD 2007−303	15.37	0.80	18.13	0.28	15.37	0.80	
WD 2008−600	17.10	0.40	...	...	17.10	0.40	
WD 2032+248	14.66	0.29	15.82	0.12	15.65	0.11	a
WD 2047+372	...	...	17.77	0.66	17.77	0.66	
WD 2048+263	20.08	1.37	19.62	1.65	19.89	1.05	a
WD 2054−050	17.06	0.73	15.34	1.28	17.06	0.73	
WD 2105−820	17.06	2.56	18.13	0.28	18.12	0.28	a
WD 2117+539	19.72	2.88	17.82	0.51	17.88	0.50	a
WD 2138−332	...	...	17.3	2.7	17.3	2.7	
WD 2140+207	12.52	0.50	...	...	12.52	0.50	
WD 2154−512	16.36	0.71	...	...	16.36	0.71	
WD 2159−754	...	...	14.24	1.58	14.24	1.58	
WD 2211−392	18.80	0.78	...	...	18.80	0.78	
WD 2226−754	...	...	12.8	2.2	12.8	2.2	
WD 2226−755	...	...	14.0	2.2	14.0	2.2	
WD 2246+223	19.05	1.49	15.64	0.28	19.05	1.49	
WD 2251−070	8.08	0.28	7.75	0.37	8.08	0.28	
WD 2322+137	...	...	18.76	6.00	18.76	6.00	
WD 2326+049	13.62	0.74	16.33	0.23	13.62	0.74	
WD 2336−079	...	...	17.45	0.61	17.45	0.61	
WD 2341+322	17.61	0.56	19.37	0.67	17.61	0.56	
WD 2359−434	7.85	0.42	6.12	0.59	7.85	0.42	

Note. [a] Weighted mean of trigonometric and photometric distance.

2.3. Trigonometric and Photometric Distances

Table 3 lists the trigonometric distance measurements and our photometric distances for the stars in our sample. Where possible we also have estimated photometric distances for each H-rich star (DA and DC and DAZ stars). In contrast to the empirical color–magnitude relation based distance estimates used by HOS, we have employed much more precise distance estimates based on spectroscopic temperatures and surface gravities and multi-band synthetic photometry. The synthetic photometry technique is fully described in HBG and has been critically verified against trigonometric parallaxes. Briefly, we use the precise photometric calibrations of DA stars on the Vega *Hubble Space Telescope* (*HST*) photometric scale, and calculate distance moduli in various available photometric bands; *UBVRI*, 2MASS JHK_s, and SDSS *ugriz*. It is a prerequisite that these multi-band distance moduli mutually agree for a distance to be adopted. Many of the photometric distances in Table 3 are taken directly from HBG. We also provide a final adopted distance and uncertainty using either the trigonometric or photometric distance, or the weighted mean of the two.

2.4. Comments on Individual Stars

WD 0121−429. Subasavage et al. (2007) have noted Zeeman splitting in the Hα and Hβ lines of this star. A preliminary trigonometric parallax distance of 17.7 ± 0.7 pc and an implied mass of 0.43 ± 0.3 $M_\odot$ are given, raising the possibility that this star could be a helium core white dwarf and a member of a double degenerate system.

WD 0135−052. This is a well-known unresolved double-degenerate spectroscopic system composed of two DA stars of similar temperature (Saffer et al. 1988). It thus appears over luminous relative to its temperature and gravity.

WD 0310−668. Kawka et al. (2007) reported a possible detection of a 6 kG magnetic field in this star. We follow Kawka et al. in not including this star among the white dwarfs with known magnetic fields.

WD 0413−077. 40 Eri B is a well-known DA white dwarf with well-determined but inconsistent Yale and *Hipparcos* trigonometric parallaxes. Valyvin et al. (2003) report the existence of a small magnetic field of a few kG. We follow Kawka et al. (2007) and include this star among the known magnetic white dwarfs.

WD 0423+120. The parallax and photometric distances strongly disagree (17.36 versus 11.88 pc respectively) making the star appear overly luminous. This strongly suggests that the star may be a double degenerate. If we assume it is composed of two equally luminous white dwarfs, the photometric distance becomes 16.8 pc, in good agreement with the parallax distance.

WD 0644+375. The parallax distance and the photometric distances (15.41 ± 0.70 and 18.42 ± 0.28, respectively) are not in satisfactory agreement. The *Hipparcos* and the Yale parallaxes both agree and therefore would seem to be secure. This leaves the photometric distance estimate in doubt. The star has three highly consistent spectroscopic determinations of its temperature and gravity, yet the star appears under luminous by about 43%.

WD 0743−336. This is a Sirius-like system composed of a G0V primary, HR 3018 (Kunkel et al. 1984).

WD 0806−661. This is an extreme DQ star for which no reliable spectroscopic analysis presently exists. The assumed mass is the mean of the DQ star masses found by Dufour et al. (2005). Although the photometric distance to this star is 21.1 ± 3.5 pc, the preliminary photometric distance is within 20 pc.

WD 0839−327. Bragaglia et al. (1990) noted possible radial variations in the DA star and suggested that it was a double degenerate system. Kawka et al. (2007) determined a photometric distance of 7 pc for this star, significantly less than the trigonometric parallax estimate of 8.87 ± 0.77 pc and estimated the temperature and absolute magnitude of a putative degenerate companion. We find a high level of consistency between our photometric distance (8.48 ± 0.37 pc) and the trigonometric distance. If this star is a double-degenerate system, then the companion must be very cool and faint.

WD 1009−184. A newly recognized Sirius-like system. The primary LHS 2231 is a K7V star (Hawley et al. 1996). Our distance comes from the Hipparcos parallax of the primary. Recent RECONS measurements of WD 1009−184 show it to be a wide common proper motion of companion LHS 2231.

WD 1033+714. There are relatively little observational data on this star. It is listed as a DC9 and its distance is determined photometrically in Liebert et al. (1988). We have used the available *BVRI* and 2MASS JHK_s data to re-estimate the effective temperature of 5000 ± 500 K and to determine the distance, based on the assumption that the gravity is $\log g = 8.0 \pm 0.3$.

WD 1124+595. GD 309 (SDSS_J112652.43+591917.0) is a DA with a photometric distance of less than 20 pc. It is not presently listed as a white dwarf in *The White Dwarf Catalog*.[5] Eisenstein et al. (2006) find GD 309 to be a 10,500 K DA white dwarf with a g-band magnitude of 15.2. The photometric distance calculated by HBG is 17.9 pc.

WD 1132−325. The distance for the white dwarf in this Sirius-like system comes from the Hipparcos parallax of the K0V companion (VB 4, LHS 308, HIP 56472). The spectral type and parameters of the white dwarf are uncertain; Henry et al. (2002) suggest it is a DC.

WD 1544−377. This object is a white dwarf in a Sirius-like system containing the G6V common proper motion companion HR5865 found by Luyten (1969) and studied by Wegner (1973).

WD 1620−391. There is an inconsistency between the *Hipparcos* and the Yale parallaxes for this DA white dwarf. *Hipparcos* gives $\pi = 78.04 \pm 2.07$ mas while Yale gives $\pi = 65.5 \pm 7.1$ mas. Significantly, this discrepancy is also reflected in the parallaxes of the G5 V common proper motion companion (HR 6094) of WD 1620−391, where the corresponding values are 77.69 ± 0.76 mas and 63.5 ± 10.1 mas. A weighted mean of the more precise *Hipparcos* parallaxes for both stars gives a distance estimate for the white dwarf of 12.87 ± 0.05 pc. This distance is fully consistent with the photometric distance of 13.03 ± 0.03 pc.). Adopting the mean Yale parallax of the system yields a distance of 15.44 pc which would imply that the star is overluminous by a factor of 1.5. WD 1620−391 is a well-studied DA white dwarf used as a spectrophotometric standard star, and there is no spectroscopic or other evidence that it is in fact overluminous. Indeed, it is possible to match its entire spectral energy distribution with a single model atmosphere from the extreme ultraviolet to the near infrared (Sing et al. 2002). We conclude that the Yale parallaxes for WD 1620−391 and HR 6094 are underestimates.

WD 1814+134. This is a high proper motion white dwarf identified as LSR J1817+1328 in Lépine et al. (2003), who estimated a distance of 18 ± 9 pc. Lépine (2007, private communication) has obtained a preliminary parallax that is consistent with the photometric distance of 15.6 ± 2.5 pc found by Subasavage et al. (2007).

WD 2007−303. Jordan et al. (2007) note a possible 2σ detection of a 2.4 kG magnetic field in this star. However, until this can be confirmed, we list it as non-magnetic.

WD 2008−600. Subasavage et al. (2007) estimate a photometric temperature (5078 ± 221 K) for this DC star, as well as a preliminary trigonometric parallax of 17.1 ± 0.4 pc.

WD 2048+263. BRL suspected this to be a double-degenerate system. Their conclusion was based on the low gravity and mass, as well as the suspected dilution of the Balmer Hα profile of the

[5] http://www.astronomy.villanova.edu/WDCatalog/index.html.

Table 4
Possible White Dwarfs within 20 pc

WD No.	Alt ID	Spec	Trig. (pc)	σ (pc)	Phot (pc)	σ (pc)	Ref.	V	Notes
WD 0101+048	G 1–45	DA5	21.32	1.73	14.38	0.43	1	14.031	a, c
WD 0236+259	NLTT 8581	DA9.2	...	...	20.4	4.3	4	15.54	c
WD 0243−026	LHS 1442	DA7	21.23	2.25	22.11	1.4	1	15.52	c
WD 0255−705	LHS 1474	DA4.7	...	...	23.84	0.8	5	14.08	c
WD 0419−487	RR Cae	DA6.7	...	...	21.05	1.05	8	14.36	b, c
WD 0503−174	LHS 1734	DAH9.5	21.93	1.92	21.33	2.2	1	15.99	c
WD 0532+414	GD 69	DA6.8	...	...	19.34	0.75	3	15.771	a, c
WD 0810+489	NLTT 19138	DC6.9	...	...	20.81	7.94	4	15.74 :	c
WD 0816−310	SCR 0818–3110	...	...	...	23.8	3.1	9	...	c
WD 0827+387	...	...	...	...	20.02	0.57	7	...	
WD 0843+358	GD 95	DZ6	...	...	23.1	...	3	14.83	
WD 0856+331	G 47–18	DQ5.1	22.32	1.69	23.64	1.9	1	15.301	c
WD 0939+071	PG 0939+072	DC7	...	...	18.9	...	3	14.91	
WD 0946+534	G195–42	DQ6	22.99	1.85	23.0	...	1	15.199	
WD 1208+576	LHS 2522	DAZ8.6	20.45	1.92	20.24	2	1	15.78	c
WD 1242−105	NLTT 31748	DA6.3	...	...	24.53	2.07	3	14.43	c
WD 1310+583	PG 1310+583	DA4.8	...	...	20.2	0.6	3	...	c
WD 1315−781	NLTT 33551	DC8.8	...	...	21.6	3.5	6	16.16	
WD 1339+259	PM J134020–3415	DA9.5	...	...	21.2	3.5	6, 9	16.43	
WD 1350−090	LP 907–37	DA5	...	...	19.34	0.69	3	14.55	c
WD 1425−811	APM 784	DAV4.2	...	...	19.19	0.7	5	13.75	c
WD 1529+141	NLTT 40489	DA9.6	...	...	22	...	4	16.56 :	
WD 1538+333	NLTT 40881	DA5.6	...	...	21.06	1.7	4	15.03 :	c
WD 1657+321	NLTT 43985	DA7.8	...	...	29	5	4	16.92 :	
WD 1729+371	NLTT 44986	DA7	...	...	22	...	4	16.23 :	
WD 1756+143	LSR 17581417	DA9.0	...	...	22.4	3.4	6	16.8	
WD 2039−202	L 711–10	DA3	22.78	1.86	20.88	0.40	2	12.354	c
WD 2039−682	BPM13491	DA3.1	...	...	22	...	5	12.40	
WD 2040−392	NLTT 49752	DA4.5	...	...	23.1	4.0	6	13.74	
WD 2048−250	NLTT 49985	DA6.6	...	...	22.3	0.8	4	15.42 :	c
WD 2115−560	APM 27273	DA6	...	...	20	...	5	14.28	
WD 2126+734	G 261–43	DA6	21.23	1.08	22.49	0.5	1	12.829	c
WD 2151−015	G 93–53	DA6	...	...	20.97	1.21	3	14.55	b, c
WD 2215+386	NLTT 53447	DC10.6	...	...	20	...	4	16.99 :	
WD 2248+293	LHS 529	DA9.2	20.92	1.84	20.51	0.94	1	...	c
WD 2347+292	LHS 3019	DA8.6	21.51	1.90	20.52	2.06	1	15.737	c
WD 2351−335	LHS 4040	DA5.7	...	...	17.11	0.50	3	...	b, c

Notes.
[a] Double degenerate; [b] binary; [c] photometric distances estimated in this paper.
References. (1) Van Altena et al. (1994); (2) Perryman (1997); (3) Farihi, et al. (2005); (4) Kawka & Vennes (2006); (5) Kawka et al. (2007); (6) Subasavage et al. (2007); (7) HBG; (8) Subasavage et al. (2008, in preparation) and this paper; (9) Lépine et al. (2005).

visible DA white dwarf by a possible DC companion. We find the photometric distance to match the trigonometric distance. Thus, the star does not appear over-luminous, so the contribution from any putative companion appears to be minimal. Therefore we list the star as single.

WD 2138−332. This is a calcium-rich DZ white dwarf. Subasavage et al. (2007) estimate a photometric temperature (7188 ± 291 K) for this DZ star, as well as a photometric distance of 17.3 ± 2.7 pc.

WD 2226−754. This is a member of a double-degenerate system which includes WD 2226−755. Our independent photometric distances for the two stars are 12.8 ± 2.2 and 14.0 ± 2.2 pc, respectively. We have not formally included WD 2226−754 in our list of stars within 13 pc because preliminary trigonometric parallaxes indicate that both stars lie somewhat beyond 13 pc.

3. WHITE DWARFS POSSIBLY WITHIN 20 PC

In Table 4 we list a set of 36 stars whose present trigonometric and or photometric distances, given the estimated distance uncertainties, allow for a significant probability that they may actually lie within 20 pc. Although several of the stars have distance estimates less than 20 pc, at present we do not regard these as sufficiently well-determined to include them in the local sample. In addition to the stars in Table 4, WD 1241−798, which Henry et al. (2004) refer to as LHS 2621, has been confirmed as a white dwarf. Preliminary parallax measurements (Subasavage et al. 2008, in preparation) indicate it may be closer than 20 pc. One interesting entry in Table 4 is WD 0419−487, the 7.3 h eclipsing white dwarf red + dwarf system RR Cae. Using the radial velocity and light curve data for the system, Bruch (1999) estimated its distance at 11 pc. Recently, Maxted et al. (2007) conducted an exhaustive study of this system and estimate the white dwarf mass to be 0.440 ± 0.022 $M_\odot$. They also determined the respective $T_{\rm eff}$ and log g to be 7540 ± 175 K and 7.67 − 7.72 ± 0.06. Using these parameters, the published *UBV* data (Eggen 1969), Strömgren *y* magnitude (Wegner 1979), and assuming no significant contamination from the M star, we calculate a photometric distance of 21.05 ± 1.0 pc. This is in good agreement with a prelim-

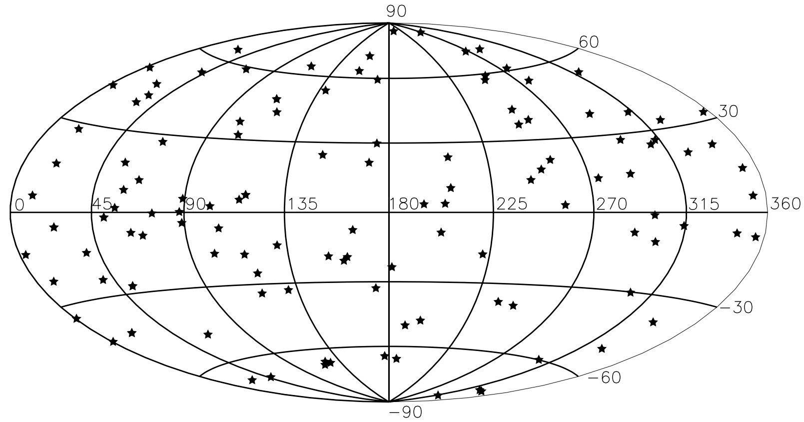

Figure 1. Hammer–Aitoff equal area projection of the equatorial coordinates of the local sample of white dwarfs from Table 1 within 20 pc of the Sun.

inary trigonometric parallax from (Subasavage et al. 2008, in preparation).

The stars in Table 4 are those where additional trigonometric and/or spectroscopic observations could refine and improve the distances and uncertainties. We use the stars in this list, in a statistical sense, to help define the local white dwarf population.

4. STATIC PROPERTIES OF THE LOCAL SAMPLE

In HOS a simple count of white dwarfs within a volume of 13 pc was employed, where the sample was demonstrated to be complete, in order to determine the local space density of white dwarfs. Here we employ a slightly more sophisticated determination of both the number of stars within 13 pc and those within 20 pc. Since we have estimated the uncertainties associated with each distance estimate, this information can be used to determine the probability that a given star lies within a volume bounded by a given radius. The star count is thus the sum of these probabilities. This mitigates the effect of stars near a particular boundary contributing a bias to the star count. Basically we replace each star by a Gaussian probability distribution with a centroid at the star's radius and a width defined by the uncertainty. For example, stars lying just inside and outside of 13 pc will contribute fractionally to the stellar density determination.

4.1. Homogeneity, Distribution, and Completeness

As in HOS, we display the distribution in celestial coordinates of the local sample on an equal-area Hammer–Aitoff projection (see Figure 1). HOS found a ∼5:4 preponderance of stars in the northern hemisphere versus those in the southern hemisphere for 109 stars. With 126 stars we find a slightly smaller ratio, with 68 stars north of the equator versus 58 south. We have also calculated the location of the centroid of the local sample: $\alpha = 29.9^\circ$ and $\delta = +37.3^\circ$ with a distance of 1.98 pc. The expected offset distance for 126 stars, based on a fully isotropic distribution, is 1.38 pc. Thus, there is a $\sim 2\sigma$ displacement in a generally northward direction with respect to the Sun.

HOS argued that the sample of known white dwarfs within a radius of 13 pc was complete. Since that time six stars from that sample (see the Appendix) either moved outside the 13 pc boundary, or turned out not to be white dwarfs. Three new stars have been added to the 13 pc sample. One of these, WD 0000−345, was in the HOS sample but simply migrated over the 13 pc boundary. However, the other two, WD 0821−688 and WD 1202−232, are new discoveries from the RECONS program (Subasavage et al. 2007). Their photometry indicates these objects are closer than 13 pc. These recent discoveries indicate that the 13 pc sample may not be fully complete and that additional stars may be found.

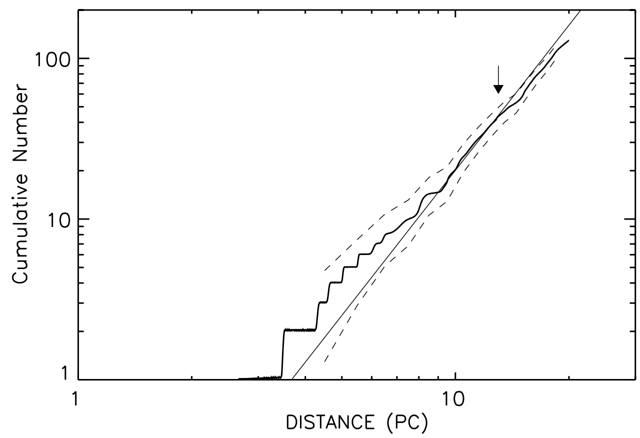

Figure 2. Cumluative log ΣN versus log (distance) plot of the white dwarfs within the local sample. The level of 1σ Poisson uncertainties is indicated by the dotted lines, while the straight line represents the expected number of white dwarfs for a uniform distribution of stars with a space density of 4.8×10^{-3} pc^{-3}. The arrow marks a radius of 13 pc corresponding to the completeness limit for the sample. The plotted distribution of stars is computed from the cumulative probability distribution of all stars in Tables 3 and 4.

Here, our space density is not explicitly based on the integer count of stars within 13 pc, but rather the normalization of the +3 log–log slope in Figure 2 with respect to the cumulative plot of the likely number of stars (based on the sum of the distance-probability distributions of the stars). Plotting probabilities rather than star numbers also mitigates the net effect of any migrations across the 13 pc boundary due to future improved distance estimates. Likewise, the uncertainty in the space density is defined to be consistent with the band of $N^{1/2}$ statistics of the sample shown in Figure 2. Any addition (or loss) of a few stars from the 13 pc sample will thus cause a proportional change in the mean stellar density, but will not significantly alter the uncertainty of the sample. Only by extending completeness out to larger distances and including more stars will the estimate of the space density be improved substantially. This situation may very well be realized in the next few years (see Section 5).

HOS estimated that the 2002 sample was 65% complete out to 20 pc. Based on our slightly larger sample and correspondingly smaller space density (see Section 4.2), we now estimate that the current 20 pc sample is ∼80% complete and that there are ∼33 ± 13 white dwarfs remaining to be discovered between 13 and 20 pc. This is shown graphically in Figure 2 were we show the cumulative log Σ*N* versus log distance plot, which is compared to the expected complete distribution with a slope of +3 and normalized at 13 pc. Some of these potential new local sample members are no doubt among the stars listed in Table 4. In plotting the cumulative distribution in Figure 2, we include the stars from Table 4 (and their distance uncertainties). We conclude from this comparison that there are likely 130.7 stars within 20 pc among those listed in both Tables 3 and 4. If we omit the stars in Table 4, and only consider those in Table 3, then the likely number of stars drops to 120.

4.2. Space Density

Using the adopted distances in Table 3 (and counting unresolved double degenerates twice) we have computed a cumulative log Σ*N* versus log distance plot (Figure 2) and compared the resulting distance distribution with a straight line of slope 3.0 expected for a distribution of stars with a uniform space density of $4.8 \pm 0.5 \times 10^{-3}$ stars pc^{-3}. This is to be compared with the space density of $5.0 \pm 0.7 \times 10^{-3}$ pc^{-3} determined from the original HOS sample. Interestingly, our revised space density is in good agreement with the value of $4.6 \pm 0.5 \times 10^{-3}$ stars pc^{-3} obtained by Harris et al. (2006) by integrating their detailed SDSS white dwarf luminosity function. We find a total of 44 white dwarfs (including double degenerates) within 13 pc (compared with 46 in HOS). The uncertainty in the space density is due to the $N^{1/2}$ Poisson statistics.

4.3. Mass, Mass Density, and Mean Mass

The mass density of white dwarfs corresponding to the space density in Section 4.2 is $3.2 \pm 0.5 \times 10^{-3}$ $M_{\odot}$ pc^{-3}. This estimate is based on the mean mass of the local sample. For the 126 stars in Table 2 the mean mass is 0.665 $M_{\odot}$, which is essentially the same as the value of 0.65 $M_{\odot}$ found by HOS. The corresponding mean surface gravity is found to be 8.132.

Both the mean mass and gravity are significantly larger than values typically found for large samples of hot DA stars. For example, LBH find a mean mass of 0.603 $M_{\odot}$ and a mean surface gravity of 7.883 from a sample of 298 DA white dwarfs with temperatures above 13,000 K. As mentioned in Section 2.2, our local sample consists largely of cool white dwarfs where spectroscopic gravities and masses where spectroscopic determinations regularly produce systematically larger estimates. In order to investigate if there is such a temperature effect evident in our data we have examined several subsamples of the local population. First, following LBH, we split the sample into two groups that have temperature estimates above and below 13,000 K. Interestingly, we find that for the 13 hot DA stars (all with spectroscopic gravities and masses) the mean mass is 0.660 $M_{\odot}$—essentially the same as the mean entire sample. However, 13 stars is a small number and perhaps the mean mass will diminish if this sample size is eventually increased by extending the boundary, from 20 to 25 or 30 pc. Nevertheless, the present sample does not show the expected temperature-related mass dependence found by LBH and Bergeron et al. (2007). The 35 stars for which we directly use the BLR masses also yield a mean mass of 0.676 $M_{\odot}$. Recall that stars in BLR have masses that are determined with respect to trigonometric parallaxes. BLR find a mean mass of 0.65 $M_{\odot}$ for their entire sample of such stars. However, BLR also find a difference between the mean-mass of the H-rich and He-rich stars, with 0.61 $M_{\odot}$ and 0.72 $M_{\odot}$, respectively. BLR attribute the lower mass of the H-rich stars to the inclusion of low mass (He-core) white dwarfs which are the product of common envelope evolution. In the local sample we find relatively equal mean masses between the H-rich and He-rich stars, with 0.68 $M_{\odot}$ and 0.64 $M_{\odot}$, respectively. The only subsample of stars in Table 2 with a somewhat smaller mean mass is the DQ and DZ white dwarf, respectively taken from Dufour et al. (2005) and Dufour et al. (2007). For these 12 stars, which also employ trigonometric parallax determined masses, we find a mean mass of 0.60 $M_{\odot}$. Another sample of stars with lower masses in Table 2 is that observed photometrically by Subasavage et al. (2007). The mean mass for this sample of 11 stars is 0.59 $M_{\odot}$; however, this result is a simple consequence of assuming log $g = 8.0$ in the analysis of these stars. In summary, the relatively larger mean mass found here appears to be a genuine feature of the local sample and not an artifact of a systematic bias due to spectroscopy or any other feature of the analysis. The question raised by this higher average mass in the local sample is what parameter other than temperature makes the critical difference between the local sample and other analyses of larger samples which are not volume-limited?One possibility is that for a given temperature higher-mass stars have smaller radii and lower luminosities and are less likely to be included in magnitude-limited samples.

4.4. Binaries

The frequency of binary systems among the local sample is of considerable interest. Thirty-one binary systems, including double degenerates, are present in the sample, giving a binary fraction of 25%. There are seven double-degenerate systems; three resolved and four unresolved, counting WD 0121−429 (Subasavage et al. 2007) as a likely unresolved system. Additionally, as mentioned in Section 2.4, WD 0423+120 is likely to be a double-degenerate system. This is approximately 6% of the entries in Table 1. Interestingly, there are now eight Sirius-like systems consisting of a white dwarf and main-sequence companions with spectral types A0V to K7V. All are resolved common proper motion pairs with six out of the eight at distances of ∼13 pc or closer. Although a small sample, this indicates that Sirius-like systems, containing K and earlier main-sequence stars, may prove at least as common as double-degenerate systems.

4.5. Spectral Types

In Table 5 we describe the contents of the local sample in terms of various categories of spectral type and binary status. The bulk of the stars (54%) are hydrogen-rich DA or DAZ stars. There is only one He-rich star with an explicit DB spectral classification (WD 1977−077, DBQA5). There are, however, 14 stars with a DQ designation, which are He-rich with spectral features due to atomic and/or molecular carbon. Thus, in Table 2 there are 81 H-rich versus 40 He-rich white dwarfs. The DC stars, which show continuous or near continuous featureless spectra, make up 19% of the sample.

Magnetic degenerates that show either Zeeman splitting (DH) or polarization (DP) make up 14% of our sample. This is in good agreement with the results of Liebert et al. (2003) who suggested upwards of 10%, if additional low field strength stars

Table 5
The Local Population of White Dwarfs

Type	Num.	Comments
DA	63	H-Rich
DAZ	11	H-Rich, trace heavy elements
DB	1	He-Rich (WD1917−077; DAQA5)
DC	24	Continuous spectra, He-rich — if cool H-rich or He-rich
DQ	15	Atomic and Molecular Carbon, He-rich
DZ	9	Heavy Elements, He-rich
DH & DP	16	Magnetic, He-rich or H-rich
WD + MS	24	White Dwarf + Main Sequence
WD + WD	7	Double-Degenerate, Resolved and Unresolved
Sirius-like	8	Sirius, Procyon, CD-38° 10980, 40 Eri B, VB 3, VB 4, WD1544−377, WD1009−184

are to be found. Kawka et al. (2003, 2007) looked carefully at the question of the magnetic fraction and searched for low field strength stars. Kawka et al. (2007) identified 15 magnetic white dwarfs within 20 pc. All of the Kawka et al. stars are included in our sample, but we have identified an additional star: WD 0121−429; Subasavage et al. (2007). Jordan et al. (2007) have also searched for low-level kG magnetic fields in a number of white dwarfs, including five DA stars in our local sample. These authors find few, if any, new examples and estimate that the fraction of low field kG stars to be 11–15%.

5. DISCUSSION

Recently, SPN have constructed a model of the thin-disc white dwarf population out to 100 pc. In doing this they began with a local thin-disc stellar population, a star-formation history, a description of post-main-sequence stellar evolution, including mass loss and an initial mass–final mass relation, followed by white dwarf cooling models. They also include galactic dynamics to allow for the diffusion of white dwarfs into orbits above the galactic plane. From this synthetic volume-limited sample they estimate a magnitude-limited sample that can be compared with existing and future magnitude-limited samples.

An essential step in constructing the magnitude-limited sample is to account for the significant fraction of cool white dwarfs which are largely excluded from magnitude-limited samples. SPN accomplish this by making a temperature cut at 6300 K and calculating the ratio (R_{6300}) of stars cooler than this temperature to those hotter. For their favored synthetic model they find $R_{6300} = 0.77$. They go on to test this model against the local population of white dwarfs described in HOS. HOS did not explicitly include white dwarf temperatures; therefore SPN used published spectroscopic temperatures, augmented with color temperatures derived from $B - V$. They found (after excluding several stars, see the Appendix) that the empirical value of R_{6300} for 102 stars was 0.68 ± 0.24, in reasonable agreement with R_{6300} from their theoretical sample.

Our present local population is significantly larger than that considered by SPN (102 versus 126 stars). Moreover, there are six stars in the SPN sample that are now known to be beyond 20 pc. In Table 2 we provide spectroscopy-based (or in a few cases multi-band photometry-based) temperature estimates for all but two of our stars. With this information it is possible to make a much more robust empirical determination of R_{6300}. We find $R_{6300} = 53{:}67 = 0.79 \pm 0.15$, in excellent agreement with the synthetic white dwarf population model used by SPN.

In summary, we have re-examined the local population of white dwarfs within 20 pc of the Sun and find 126 stars in this volume. The corresponding space and mass densities of degenerate stars are $4.8 \pm 0.5 \times 10^{-3}$ pc^{-3} and $3.2 \pm 0.3 \times 10^{-3}$ $M_{\odot}$ pc^{-3}, respectively. We also found that 25% of the sample are members of binary (or multiple) systems, with 6% each in double degenerate systems and 6.5% in Sirius-like systems. In terms of spectral types, 54% of the sample are hydrogen-rich DA or DAZ stars. However, from published compositions we find 69% to be H-rich. For other spectral types we find 12% are DQ, 7% DZ and 14% are magnetic. Significantly, we find no difference between the mean mass of all the stars in our sample (0.665 $M_{\odot}$) and the 13 stars with temperatures in excess of 13,000 K (0.658 $M_{\odot}$). This result is considerably different from prior work that indicates spectroscopic masses systematically increase for degenerates below 13,000 K.

Most significantly, the completeness of our 20 pc sample has now risen to 80%. To facilitate the search for additional members of this sample we have included a list of stars with a significant probability of being closer than 20 pc. Given the observational attention that nearby white dwarfs are presently receiving in both the northern and southern hemispheres it should not be long before the 20 pc sample can be considered virtually complete and attention can focus on the 25 pc horizon. Finally, most of the 20 pc sample stars now have accurate trigonometric distances and the prospect is good that virtually all will achieve this status within the next several years. These and other observational contributions will help give a more accurate picture of the nature of the local population.

In this paper we have primarily discussed the static properties of the local population; the stellar density, the mass density and the characteristics of the white dwarfs within 20 pc of the Sun. The present study can also be used as a starting point for further work, for example, a consideration of the kinematic and evolutionary properties of the local population. These topics will be discussed in additional papers.

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Table A1
Stars Removed from the List of Holberg et al. (2002)

WD number	Sp. type	HOS distance (pc)	New distance (pc)	New type	Ref.
WD 0235+064	DA6.8	16.84	>20	WD+rd	3
WD 0311−543	DZ7	12.15		F5V	1
WD 0419−487	DA8	8.19	21±1	DA6.7	4
WD 0509+168	DA	8.5		F2V	1
WD 0532+414	DA7	18.38	>20		3
WD 0628−020	DA	10.81			2
WD 0939+071	DA2	18.88	22		6
WD 1013−559	DZ9	11.54		F3V	1
WD 1717−345	DA	17.26	110	WD+rd	1
WD 2007−219	DA6	18.22	>20		5
WD 2249−105	DC11.5	15.26	>20	WD+rd	3
WD 2351−335	DA5	7.85	>20		5

References. (1) Kawka et al. (2004); (2) Schröder et al. (2004), (3) C. Dahn (2007, private communication); (4) Maxted et al. (2007) and this paper (see Section 3); (5) Subasavage et al. (2007); (6) this paper.

APPENDIX

CHANGES WITH RESPECT TO HOS

Eleven stars have been removed from the original HOS list. In Table A1 we list these stars with their original distance estimates and spectroscopic designations. We also list the references and reasons for the removal of these stars.

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