A Census of White Dwarfs Within 40 Parsecs of the Sun

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Abstract. Our aim is to compile a catalog of white dwarfs within 40 parsecs of the Sun, in which newly discovered objects would significantly increase the completeness of the current census. White dwarf candidates are identified from the SUPERBLINK proper motion database ([2]), which allows us to investigate stars down to a proper motion limit as low as 40 mas yr⁻¹. The selection criteria and distance estimates are based on a combination of color-magnitude and reduced proper motion diagrams. Candidates with distances less than 50 parsecs are selected for spectroscopic follow-up. We present our preliminary sample of spectroscopically confirmed white dwarfs, as well as their atmospheric parameters. These parameters are obtained using the spectroscopic technique developed in [8] for DA stars. DB, DQ, and DZ stars are also analyzed spectroscopically. For featureless spectra as well as those showing only Hα, we perform a detailed photometric analysis of their energy distribution.

Keywords: white dwarfs, spectroscopy, color, reduced proper motion, distance
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INTRODUCTION

The current census of nearby white dwarfs is complete to within 20 parsecs from the Sun, and contains 126 white dwarfs [1]. Since it represents a sample too small for detailed statistical analysis, there is a need to extend the complete sample of white dwarfs to a larger volume. Nearby white dwarfs have been traditionally found in catalogs of stars with large proper motions. In order to improve the statistics of the local white dwarf population, we have been hunting for white dwarfs in the SUPERBLINK catalog.

The SUPERBLINK proper motion database [2] is based on a re-analysis of the POSS-I and POSS-II plates of the Digitized Sky Survey (20-45 yr baseline). Its 1.3 million stars in the Northern sky were identified with a detection level > 95% down to V = 19, and a proper motion limit as low as 0.04″ yr⁻¹. Because of its low proper motion limit, the SUPERBLINK sample effectively eliminates the kinematic bias of the Luyten catalogs, while detecting all white dwarfs down to the luminosity function turn-off.

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FIGURE 1. Optical spectra for a subset of 19 stars from our new WD sample. This sample shows 17 DA stars, and 2 featureless DC white dwarfs. The DA sample includes 4 DA+dM (PM I16171+0530, LSPM J0655+5920, PM I04586+6209 and PM I23283+3319) and two magnetic white dwarfs (PM I06019+3726 and PM I15164+2803).

FIGURE 2. Color-color diagram showing the WD candidates and the spectroscopically confirmed WD from our study. The solid curves show model atmospheres for WD with a pure H atmosphere for log g=7.0, 8.0 and 9.0. The dashed curve represents a model for a pure He atmosphere with log g=8.0.

SELECTION METHOD

The first step of our analysis was to gather information about SUBERBLINK stars, as a complement to photographic $B_F$, $R_I$ and $I_N$ measurements, J2000 coordinates, and proper motions available for each SUPERBLINK star (see [2]). Catalogs were queried in order to obtain GALEX far-UV ($F_{UV}$) and near-UV ($N_{UV}$) [4], SDSS $ugriz$ [3] or 2MASS $JHK$ [6] photometry. Apparent $V$ magnitudes are estimated using the empirical relation $V = 0.54 B_F + 0.45 R_I$. Stars are then placed in $H_g$ vs $(g-z)$, $H_V$ vs $(V-J)$ or $H_V$ vs $(N_{UV} - V)$ reduced proper motion diagrams, depending on the available photometry.
for each object. When possible, cross-correlations between the diagrams are performed. Selection criteria are applied based on each star’s position in the diagram (more details will be given in Limoges et al. 2011, in preparation). Finally, confirmed white dwarfs from [5] are used to obtain color-magnitude calibrations, from which we determine an absolute magnitude and photometric distance for each candidate. Candidates with distance estimates less than 50 parsecs were selected for spectroscopic follow-up.

All spectra have been obtained at Kitt Peak with the Steward Observatory 2.3-m telescope, and the NOAO Mayall 4-m and 2.1-m telescopes. The adopted configurations allow a spectral coverage of $\lambda \lambda 3200$–5300 and $\lambda \lambda 3800$–6700, at a mean resolution of $\sim 6$ Å FWHM. A subset of DA and DC stars from our sample of new white dwarfs is shown in Figure 1. In Figure 2, a color-color diagram displays the confirmed white dwarfs and candidates for which $ugriz$ data were available. A summary of the spectral types for the 137 new white dwarfs is shown in Table 1. Finally, a sample of the detailed list of our new white dwarfs, including astrometry and spectral type is given in Table 2.\(^2\)

### RESULTS

From our list of candidates, 137 white dwarfs\(^3\) were found. Most of these objects were already part of the literature, without spectral type or white dwarf status confirmation. The atmospheric parameters ($T_{\text{eff}}$ and $\log g$) of 114 stars were measured. DA stars

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\(^2\) The complete version is available on www.astro.umontreal.ca/~limoges/

\(^3\) The DC companions in DA+DC systems are still candidates. They are not included in the total.
FIGURE 3. Top panel: Spectroscopic masses of DA white dwarfs in our sample as a function of $T_{\text{eff}}$. Bottom panel: Photometric estimates of $T_{\text{eff}}$; since no parallax measurements are available, $\log g$ is fixed at 8.0. The squares represent white dwarfs that were already known.

were analyzed using the spectroscopic fitting technique described at length in [7] and references therein. Detailed photometric analyses of their energy distributions [9] were performed for cooler objects showing only the $\text{H} \alpha$ hydrogen line and featureless DC stars. Our results are summarized in Figure 3 in a mass vs $\log T_{\text{eff}}$ diagram. Distances were then derived from the atmospheric parameters. It was found that 82 stars are closer than 50 parsecs, and 57 are within 40 parsecs. The remaining 23 cool stars will be analyzed as soon as we acquire the photometric measurements. Figures 2 and 3 demonstrate the effectiveness of our method in detecting cool white dwarfs. We are now reaching the bottom of the luminosity distribution, and on our way to obtaining a statistically complete sample of nearby white dwarfs.

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REFERENCES

1. Holberg, J. B., Sion, E. M., Oswalt, T., McCook, G. P., Foran, S., & Subasavage, J. P. 2008, ApJ, 135, 1225
2. Lépine, S., & Shara, M. M. 2005, AJ, 129, 1483
3. Adelman-McCarthy, J.K.; et al. 2009, VizieR On-line Data Catalog, 2294
4. Gil de Paz et al. 2009, VizieR On-line Data Catalog, 21730185
5. McCook, G.P., & Sion, E.M. 2006 Vizier Online Data Catalog. 3235
6. Skrutskie, M.F. et al. 2006, AJ, 131, 1163
7. Liebert, J., Bergeron, P. & Holberg, J. B. 2005 ApJ, 156 47
8. Bergeron, P., Saffer, R. & Liebert, J. 1992, ApJ, 394 247
9. Bergeron, P., Leggett, S. K., & Ruiz, M. T. 2001, ApJS, 133, 413