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The Montreal White Dwarf Database: A Tool for the Community

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Abstract. We present the "Montreal White Dwarf Database"[1] (MWDD), an accessible database with sortable/filterable table and interactive plots that will, when fully completed, allow the community to explore the physical properties of all white dwarfs ever analyzed by the Montreal group, as well as display data and analyses from the literature. We present its current capability and show how it will continuously be updated to instantly reflect improvements made on both the theoretical and observational fronts.

1. Introduction

The last decade or so has seen a dramatic increase in the number of spectroscopically identified white dwarf stars, going from about 2500 at the beginning of the millennium to around 30 000 at the time of this writing. For many years, one of the most important place to look for information about white dwarf stars has been the George P. McCook and Edward M. Sion White Dwarf Catalog (www.astronomy.villanova.edu/WDcatalog/). However, this catalog currently contains "only" 14294 objects (it was last updated in 2013), leaving many new SDSS white dwarfs behind. Moreover, this invaluable resource contains very little information on the physical parameters published in the literature.

As a result of the huge amount of data and analyses now available, keeping an eye on the big picture has become increasingly difficult. Many basic questions now require a tremendous amount of work just to get updated and obtain accurate answers. Questions such as: How complete is the census of white dwarfs within a given distance of the Sun? How many have metals, are magnetic, are in binary systems, or are He-rich? What fraction of these are there as a function of effective temperature? What are the properties of any given population? What are their mass distributions, luminosity functions, etc.? To answer those questions, one usually needs to compile all the information from the literature, double check it, look out for updates, and assess how recent data/models change the picture. This is a very time-consuming task that has to be repeated again and again as time moves forward. Even the most comprehensive efforts are practically out-of-date very soon after they are published (for the local sample, Holberg et al. 2008; Giammichele et al. 2012, come to mind).

[1] www.montrealwhitedwarfdatabase.org

A tool that would allow to easily get answers to those basic questions would certainly be useful to all of us. This is why we decided to make good use of the little surplus money from our organization of the previous workshop in Montreal and give it back to the community by creating this database. In what follows we present the main characteristics of MWDD as well as our vision of it in the near future.

2. Database Description

The Montreal White Dwarf Database aims to gather in one place all the information and available data about the spectroscopically identified white dwarfs that have been discovered to this day. Interactive tables and tools to easily make plots, histograms or display data have also been implemented (see below). The structure and philosophy behind MWDD was inspired in parts by other databases available to the exoplanets community such as `www.openexoplanetcatalogue.com/` and `exoplanets.org/`.

We constructed a compilation of known white dwarf stars by simply copying in spreadsheets (one .csv file per paper/source) all the information (names, magnitudes, effective temperature, surface gravity, abundances etc.) contained in the tables of well known papers that analyzed large samples (we also included compilations from a few review papers and websites). Since a star can be published under many different names, each star is assigned a unique identifier via Simbad. This allows us to automatically merge together as one entry in the database objects entered under different names in different papers. MWDD currently includes data compiled from 120 papers for a total approaching 30 000 white dwarfs. As more papers are linked to the database its degree of completeness will improve.

2.1. Search Filters

We implemented numerous filtering options to allow anyone to quickly isolate certain types of white dwarfs of interest or do some statistics. It is currently possible to filter by numerous parameters such as coordinates, effective temperature, mass, distance and magnitude as well as some important white dwarf characteristics such as their spectral type, surface composition, variability or magnetism. Plots, histograms, statistics and the table (see below) are automatically updated to reflect the choices made in the search filter section.

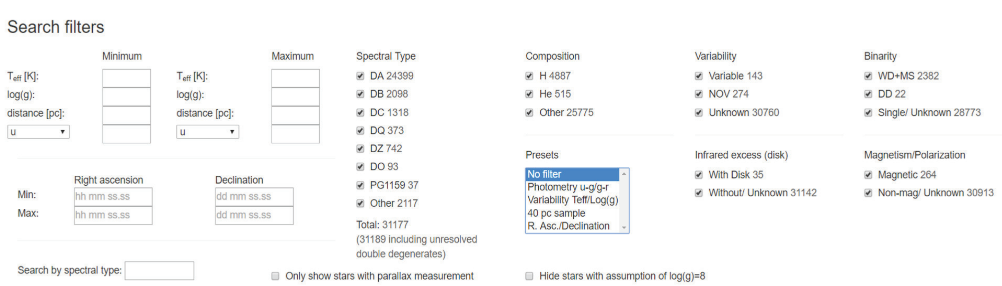
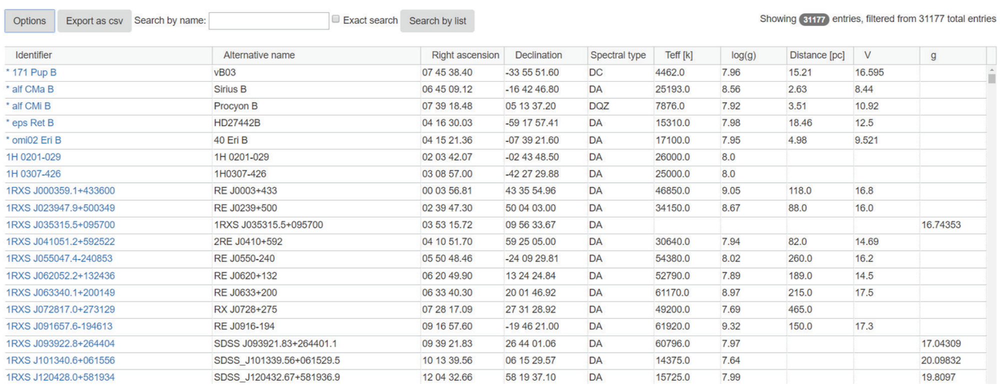


Figure 1. Filter interface in MWDD.

2.2. Table

All the properties compiled in the database can be selected and viewed via the "Table" tab. Table columns are dragable and sortable. Clicking on "Options" allow the user to select among a long list of available parameters. One can also search by name, or enter a list of names. It is also possible to export the data of all objects that pass the filters.

The values presented in the table are the last published ones (except for a few sources which have been given lower priority). In the future, a quality flag to use what we consider the best values will be implemented. Meanwhile, we encourage users to go on the individual white dwarf page in order to view the various literature values included in the database and assess themselves which parameters are to be trusted most.



Identifier	Alternative name	Right ascension	Declination	Spectral type	Teff [k]	log(g)	Distance [pc]	V	g
* 171 Pup B	vB03	07 45 38.40	-33 55 51.60	DC	4462.0	7.96	15.21	16.595	
* alf CMa B	Sirius B	06 45 09.12	-16 42 46.80	DA	25193.0	8.56	2.63	8.44	
* alf CMi B	Procyon B	07 39 18.48	05 13 37.20	DQZ	7876.0	7.92	3.51	10.92	
* eps Ret B	HD27442B	04 16 30.03	-59 17 57.41	DA	15310.0	7.98	18.46	12.5	
* omi02 Eri B	40 Eri B	04 15 21.36	-07 39 21.60	DA	17100.0	7.95	4.98	9.521	
1H 0201-029	1H 0201-029	02 03 42.07	-02 43 48.50	DA	26000.0	8.0			
1H 0307-426	1H0307-426	03 08 57.00	-42 27 29.88	DA	25000.0	8.0			
1RXS J000359.1+433600	RE J0003+433	00 03 56.81	43 35 54.96	DA	46850.0	9.05	118.0	16.8	
1RXS J023947.9+500349	RE J0239+500	02 39 47.30	50 04 03.00	DA	34150.0	8.67	88.0	16.0	
1RXS J035315.5+095700	1RXS J035315.5+095700	03 53 15.72	09 56 33.67	DA					16.74353
1RXS J041051.2+592522	2RE J0410+592	04 10 51.70	59 25 05.00	DA	30640.0	7.94	82.0	14.69	
1RXS J055047.4-240853	RE J0550-240	05 50 48.46	-24 09 29.81	DA	54380.0	8.02	260.0	16.2	
1RXS J062052.2+132436	RE J0620+132	06 20 49.90	13 24 24.84	DA	52790.0	7.89	189.0	14.5	
1RXS J063340.1+200149	RE J0633+200	06 33 40.30	20 01 46.92	DA	61170.0	8.97	215.0	17.5	
1RXS J072817.0+273129	RX J0728+275	07 28 17.09	27 31 28.92	DA	49200.0	7.69	465.0		
1RXS J091657.6-194613	RE J0916-194	09 16 57.60	-19 46 21.00	DA	61920.0	9.32	150.0	17.3	
1RXS J093922.8+264404	SDSS J093921.83+264401.1	09 39 21.83	26 44 01.06	DA	60796.0	7.97			17.04309
1RXS J101340.6+061556	SDSS_J101339.56+061529.5	10 13 39.56	06 15 29.57	DA	14375.0	7.64			20.09832
1RXS J120428.0+581934	SDSS_J120432.67+581936.9	12 04 32.66	58 19 37.10	DA	15725.0	7.99			19.8097

Figure 2. An example of the table interface.

2.3. Plots, Histograms and Statistics

JavaScript is used to make the numerous interactive plots and histograms in the user interface. The "Scatter Plot" tab allows to plot any physical quantities as a function of another. Only stars passing the selected filters will appear. Moving the mouse on an object highlights its basic atmospheric properties and clicking on it opens an individual white dwarf page (see below). It is possible to export the stars data present in a plot in order to make your own plot by selecting "Show only stars visible in Scatter Plot" in the "Table" tab.

The "Histogram" tab allows, for example, to quickly get the mass distribution of selected objects or distribution of any other variable of interests. One can also easily get a measure of the current status of our census of white dwarfs within a given distance from the Sun in the "Cumulative Number" tab (see Holberg et al. 2008). For example, by clicking on "40 pc sample" in the Presets options, one can see that we estimate a 50.0% completeness within that distance. These numbers are automatically updated as new papers are published and included in the database, allowing the community to get an instant picture of our neighborhood.

2.4. Individual White Dwarf Page

Each object in the database has an individual page (accessible via the "Table" tab, or by clicking on an object in the "Scatter Plot" tab). All the references included in the database that contain that object are listed for an easy comparison between parameters

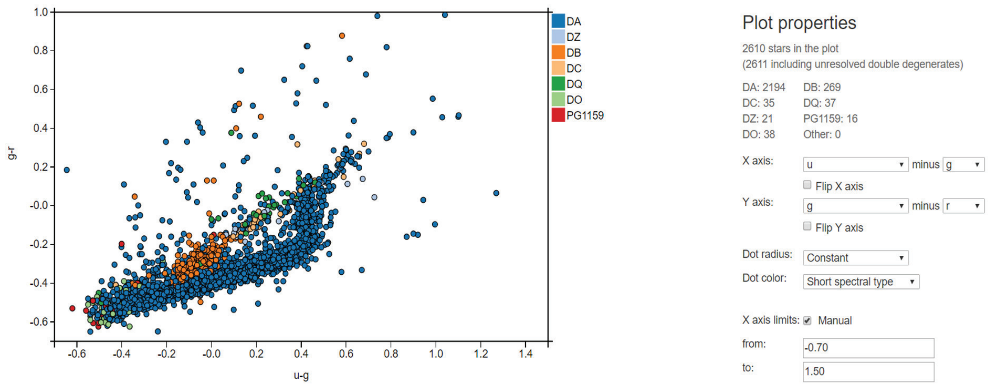


Figure 3. $u - g$ vs $g - r$ diagram for white dwarfs brighter than $g = 17.75$.

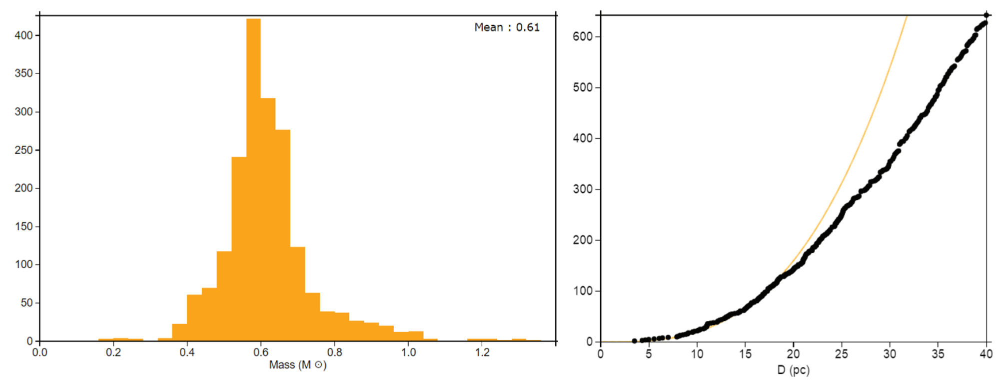


Figure 4. Mass distribution of DA white dwarfs (left) and cumulative number as a function of distance for all white dwarfs within 40 pc (right). The straight line represents the expected number of white dwarfs for a uniform space density of $4.8{\times}10^{-3}$ pc^{-3}.

from different sources. Spectroscopic data, when available, can also be visualized interactively. This includes all SDSS spectra, IUE archive data, and many of the spectra secured by the Montreal group in the last 3 decades. Optical spectra for more than 97% of the stars included in the database can currently be viewed and downloaded. We hope MWDD eventually becomes a standard repository of spectra for everyone to use. If you are in possession of worthy data and wish to share them with the community, we will be glad to link them to the database.

2.5. Evolutionary Models and Diffusion Timescales

One of the most frequent request we routinely receive concerns the white dwarf properties (mass, radius, cooling age etc.) for a given surface gravity, temperature and composition. These numbers can now be easily accessed directly on the MWDD webpage. For pedagogical purpose, a cartoon of the white dwarf size relative to Earth also automatically appears when the user enters log g/$T_{\rm eff}$. Another frequent request concerns the diffusion timescale of heavy elements at the surface of white dwarf stars.

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All names: NAME VAN MAANEN'S Star, NAME VAN MAANEN Star, GCRV 26270, PLX 160, LSPM J0049+0523, ASCC 1001769, 2MASS J00490996+0523173, USNO-B1.0 0953-00007838, 8pc 226.95, AC +05 6-75, CSI+05-00465, Ci 20 58, EGGR 5, G 1-27, G 70-16, GAT 135, GCRV 453, GEN# +9.80001027, GJ 35, HIC 3829, HIP 3829, LAWD 6, LFT 76, LHS 7, LTT 10292, NAME vMA 2, NAME VAN MAANEN 2, NLTT 2724, PM 00465+0509, UBV 668, UCAC2 33505597, USNO 690, WD 0046+05, WD 0046+051, Wolf 28, Zkh 18, uvby98 980001027, vMa 1-2, PLX 160.00

Parameter	Unit	Holberg et al. 2016	Limoges et al. 2015	Sion et al. 2014	Giammichele et al. 2012	Holberg et al. 2008	Dufour et al. 2007	Koester et al. 2005	Wolff et al. 2002	Bergeron et al. 2001	Bergeron et al. 1997	Sion et al. 1990	Liebert et al. 1987	Grenfell 1974	Weidemann 1960	Simbad
Right ascension				00 49 09.84												00 49 09.90
Declination				05 23 16.80												05 23 19.01
Spectral type		DZ	DZ	DZ7.4	DZ	DZ	DZ	DZ		DZ	DZ	DZ				DZ8
Effective temperature	[K]	6216.0 (183)	6110.0 (144)	6215.0	6215.0 (183)		6220.0 (240)	5700.0	5700.0 (200)	6770.0 (200)	6750.0 (190)	6000.0	6000.0	5800.0	5800.0	
log(g)	[cgs]	8.15 (0.03)	8.16 (0.01)		8.16 (0.03)		8.19 (0.04)	7.90	7.90 (0.2)	8.40 (0.01)	8.41 (0.01)			7.42		
Mass	[$M_\odot$]	0.68 (0.02)	0.67 (0.01)		0.68 (0.02)		0.69 (0.02)			0.83 (0.01)	0.84 (0.01)					
log(Luminosity)	[$L_\odot$]		-3.80		-3.77					-3.77 (0.01)	-3.78 (0.01)					
Cooling age	[Gyr]	3.3000			3.3000					3.6700 (0.04)	4.6600 (0.06)					
log(H/He)					-3.5		-3.19 (0.2)		-5 (0.5)				-3.0			
log(C/He)													-4.0			
log(Ca/He)					-10.16		-10.0 (0.05)	-10.7	-10.65 (0.2)				-10.6	-10.68		

Figure 5. An example of an individual white dwarf page (van Maanen 2).

Some 25 years after Paquette et al. (1986), we improved significantly on their calculations of diffusion coefficients by 1) using a much more accurate numerical scheme for estimating the so-called collision integrals, and 2) introducing a more physical prescription of the screening length used as the independent variable in the evaluation of these coefficients. Details of these improved calculations will be provided elsewhere. An interpolation routine allows the users to enter log g and $T_{\rm eff}$ and obtain the settling timescales for all 27 elements from Li to Cu in the periodic table (also downloadable as a plain text file).

2.6. What's Next?

The next step, among other things, to improve the usefulness of the database to the community will be to add the possibility to make luminosity functions and filter with S/N ratio, wavelength range coverage and resolution of the spectroscopic observations. A comment section to discuss individual object or general topics will also be implemented. We also plan to include our own results from model atmosphere fitting. In the near future, we will include photometric/spectroscopic fits and distance estimate for all simple objects present in the database (i.e. stars that can easily be fitted with a standard grid such as single DA, DB, DC and DQ stars). The homogeneity of the analysis should allow a much clearer view of the properties of white dwarf stars in general. Moreover, once all the data from the database will be directly linked with our fitting routine, it will be much easier to update the parameters whenever new data, or new grids become available. For example, when Gaia's parallaxes become available, it will be possible to provide instantly to the community the mass distribution of cool white dwarfs by simply adding one single file to the database (white dwarf names + parallaxes) and then running our fitting routines (which typically takes a few seconds per objects). More complicated stars that stand out will then be treated accordingly and included once we are satisfied with the results.

We should stress that the database is not complete (it only includes data found in a few selected papers) and should not replace in any way a thorough search through the

White dwarf spectral type: DB ▾

Envelope thickness: thin ▾

Temperature [K]: 15300

log(g) [cgs]: 8.1

Download output as plain text file: Download

White dwarf properties*

Mass	Radius	Luminosity	Cooling time	Gravitational redshift	Envelope mass ratio log(q)
0.651 $M_\odot$	0.0119 $R_\odot$	0.00695 $L_\odot$	0.232 Gyr	34.8 km/s	-5.999


Log of diffusion timescale (in years)**

H																	He
Li 5.815	Be 5.787											B 5.739	C 5.710	N 5.679	O 5.672	F 5.647	Ne 5.672
Na 5.659	Mg 5.674											Al 5.655	Si 5.651	P 5.589	S 5.567	Cl 5.521	Ar 5.459
K 5.478	Ca 5.487	Sc 5.458	Ti 5.454	V 5.453	Cr 5.469	Mn 5.468	Fe 5.482	Co 5.475	Ni 5.489	Cu 5.450	Zn	Ga	Ge	As	Se	Br	Kr

Figure 6. White dwarf properties and diffusion timescales

literature. It is nevertheless a good place to start to quickly get information about any given star. While we will periodically link new paper's data to the database, it is our hope the members of the community will participate in our efforts to make the database as complete as possible by submitting .csv files (templates are available) for their own work or interesting papers not included yet. We welcome contributions and corrections from all professional astronomers and white dwarf aficionados.

If using MWDD was useful for your research, please cite this manuscript and include an appropriate acknowledgment, a very simple action that will help us tremendously in getting the funding necessary to maintain/improve MWDD in the future.

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