THE INITIAL-FINAL MASS FUNCTION OF WHITE DWARFS IN COMMON PROPER MOTION PAIRS

S. Catalán[1,2], I. Ribas[1,2], J. Isern[1,2], E. García-Berro[1,3], C. Allende Prieto[4]

[1]Institut d'Estudis Espacials de Catalunya, Barcelona, SPAIN, [2]Institut de Ciències de l'Espai, CSIC,
[3]Universitat Politècnica de Catalunya, [4] University of Texas at Austin

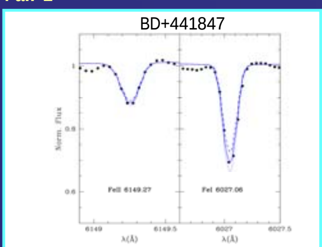
A promising approach to diminish the uncertainties in the initial-to-final mass relationship, which is still poorly constrained, is to study white dwarfs (WDs) for which external constraints are available, e.g. WDs in open clusters. In our case, we have chosen to study WDs in common proper motion pairs. Important information of the WD can be inferred from the study of the companion, since they were born at the same time and with the same chemical composition. In this poster, we report new results obtained from spectroscopic observations of both members of several common proper motion pairs (CPMPs) composed of a main sequence star (F, G or K type) and a DA white dwarf.

OBSERVATIONS AND ANALYSIS

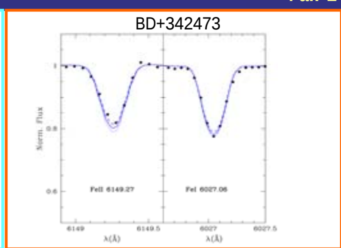
A preliminary list of targets was selected from the literature and is composed of 11 common proper motion pairs. The observations were carried out using a suite of telescope/instrument configurations. The white dwarf (WD) members were observed with the LCS spectrograph of the HJS (2.7m) telescope at McDonald Observatory (Texas) and also with the TWIN spectrograph of the 3.5m telescope at Calar Alto Observatory (CAHA, Almeria, Spain), obtaining a resolution of ~4-5 Å. The main-sequence companions were observed with the FOCES echelle spectrograph of the 2.2m telescope at CAHA and also with the SARG echelle spectrograph at the TNG telescope in la Palma (Canary Islands, Spain) obtaining a resolution of R~47000 and R~57000, respectively. These spectroscopic observations revealed that only 5 of the 11 white dwarf components were in fact of type DA, and the rest were misclassified. To further extend the sample, a cross-correlation of the SIMBAD database and the Villanova WD catalog has provided us with more pairs, which we expect to study shortly.

FGK stars

Pair 1



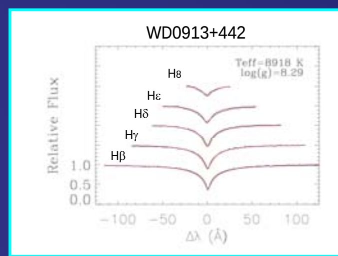
Pair 2



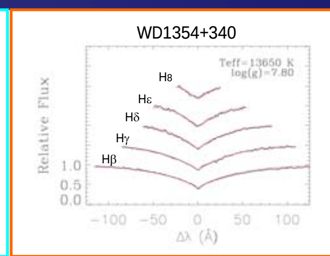
Fits of the observed spectra using synthetic spectra based on Kurucz models for two of the companions. Dots represent the observational data. The solid line is the fit corresponding to the final adopted Z and the dotted and dashed lines are spectra computed for +3σ and -3σ from the average, respectively.

White dwarfs

Pair 1



Pair 2



Model fits to the individual Balmer line profiles of two of the DA white dwarfs in our sample. In the right top of the figures, T_{eff} and log g of the best fit are indicated.

FGK star	T_{eff} (K)	Z	Age(Gyr)	t_{prog}	M_i ($M_\odot$)
G158-77*	4387 ± 27				
BD+441847	5625 ± 49	0.011 ±0.003	2.26 ±0.43	0.54 ±0.40	2.75 ±0.63
BD+232539^	5666 ± 48				
BD+342473	6268 ± 68	0.030 ±0.008	1.42 ±0.37	1.28 ± 0.38	1.89 ±0.17
BD-085980	5669 ± 52	0.012 ±0.004	2.10 ± 0.29	0.54 ±0.30	2.75 ±0.45

*Higher signal-to-noise spectra are necessary in order to be able to derive the metallicity of this star.

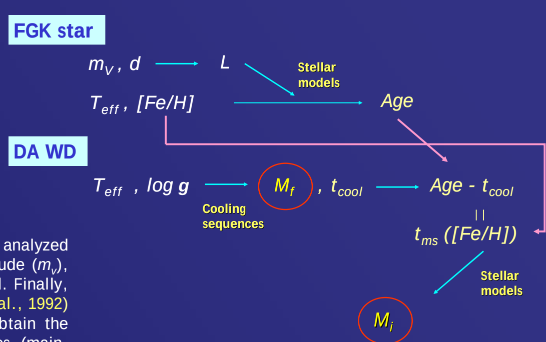
^The distance is not available for this star, hence, we need to calculate log g from the fitting of the Mg Ib triplet to synthetic spectra . This work is still in progress.

WD	T_{eff} (K)	log g(dex)	M_f ($M_\odot$)	t_{cool} (Gyr)
0023+109	10377± 230	7.92 ±0.08	0.56 ± 0.03	0.49 ± 0.08
0913+442	8918 ±111	8.29 ±0.02	0.78 ± 0.01	1.72 ± 0.06
1304+227	10798 ±120	8.21 ±0.05	0.73 ± 0.13	0.73 ± 0.06
1354+340	13650 ±437	7.80 ±0.15	0.49 ± 0.10	0.14 ± 0.02
2253-081*	7160 ±165	8.43 ±0.07	0.55 ± 0.05	1.56 ± 0.25

* The fit of this WD is specially difficult because its lines are rotationally broadened (Karl et al. 2005). We used the atmospheric parameters reported in that paper and the mass derived from the gravitational redshift by Wegner & Reid (1991).

FGK member:

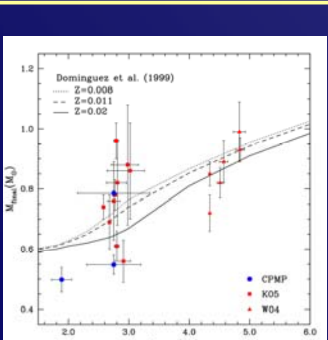
Firstly, we derived the effective temperatures (T_{eff}) of these stars using the available VJHK photometry and following the method of Masana et al. (2006) (see table above). Then, we fitted the observed spectra using the SYNSPEC program and Kurucz atmospheres to derive their metallicities. We focused on those spectral windows where unblended lines of FeI, FeII and NiI are present: 5800-5900Å, 6750-6850Å for Fe and 6100-6200Å and 7700-7800Å for Ni. For the objects analyzed here we know the distance (*d*) and the apparent magnitude (m_v), so the calculation of the luminosity (*L*) is straightforward. Finally, using the stellar models of the Geneva group (Schaller et al., 1992) we performed an interpolation using T_{eff}, *L* and *Z* to obtain the ages of these stars, and, consequently, the total ages (main-sequence phase + cooling time) of the WD members.



DA white dwarf member:

In the table above, we list the atmosphere parameters derived from the fitting of the theoretical models for DA WDs of D. Koester (private communication) to the Balmer lines using the package SPECFIT of IRAF, and following the procedure in Bergeron et al. (1992). Once we have T_{eff} and log g of each star, we derive its mass (M_f) and cooling time (t_{cool}) using the cooling tracks of Salaris et al. (2000). Since we already know the total age of the white dwarf (from the companion), we obtain the main-sequence lifetime of the progenitor (t_{ms}) by subtracting its cooling time. Finally, using the stellar models of Dominguez et al. (1999) we calculate the mass of the progenitor in the main sequence, i.e., the initial mass, M_i.

THE INITIAL-FINAL MASS FUNCTION



In this plot we represent the final mass, M_f , versus the initial mass, M_i , of the WDs in our CPMPs list for which the analysis has been completed (blue points). Also plotted are the results for the WDs in the open clusters M35 (W04, Willliams et al. 2004) and M37 (K05, Kalirai et al. 2005). We used the T_{eff} and *log g* reported by these authors and then, for internal consistency, followed the same procedure as for the WDs in our list. As can be seen, the determinations obtained using CPMPs are in good agreement with those from M37.

From the figure and tables above, it can be noticed that the errors obtained for the final masses (M_f) are higher than in the case of WDs in open clusters, however, these systems are potentially more abundant and their closeness allows a better spectroscopic study of both members of the pairs.

A thorough comparison of the semi-empirical data with some theoretical relationships, e. g. Dominguez et al. (1999) (in the plot) or Marigo (2000), is currently underway. A first inspection (see figure) reveals a large scatter in the distribution. This can be due to the fact that maybe the initial-final mass relationship is not a single-valued function. More observational data and improvement of the stellar models (mainly in the AGB phase) will help to better establish this function.