A Search for Unresolved Double Degenerates Using IUE Archives

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Abstract. We present preliminary results of a study aimed at detecting double white dwarf systems using a method based on a comparison of optical and UV spectra for 141 DA stars drawn from the IUE archives. In particular, we are looking for discrepancies between optical and UV temperatures. Even though known unresolved degenerate binaries stand out in this comparison, most temperature differences can probably be attributed to the presence of reddening, or the presence of heavy elements. We are in the process of securing additional optical spectroscopic observations to increase the number of stars in our analysis.

1. Introduction

Stellar evolution theory predicts that there should exist a population of white dwarfs in binary systems with combined masses exceeding the Chandrasekhar limit. If such systems have a short enough orbital period, merger within a Hubble time will make them possible candidates for type Ia supernovae progenitors. The problem is that very few double degenerates (DDs) are actually known to account for the observed type Ia supernovae rate. We present the results of a possible new method for detecting DDs based on the comparison of optical and UV spectroscopic temperatures. In particular, we are looking for discrepancies between these two temperature estimates, which may indicate the presence of more than one white dwarf in the system.

2. Sample and Mass Distribution

Our sample consists of DA stars drawn from the IUE archive data of Holberg et al. (2003). So far we have secured optical spectra for 141 objects, and we plan to secure similar data for all white dwarfs in the Northern hemisphere. The effective temperatures and surface gravities are first obtained by fitting simultaneously the H\(\beta\) to H8 Balmer line profiles using the spectroscopic technique described in Bergeron et al. (1992). Our model atmospheres assume a pure hydrogen composition, take into account NLTE effects and include convective energy transport. Masses are also obtained using the evolutionary models of Wood (1995) with thick hydrogen layers. Figure 1 presents the mass distribution as a function of log\(T_{\text{eff}}\). Surprisingly, our sample contains very few low-mass stars, in contrast with the results of other spectroscopic investigations. Our sample contains only two very low mass objects, WD 1022+050 (LP 550–52) a known double degenerate (Maxted & Marsh 1999), and WD 0943+441 (G116–52).
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Figure 1. Distribution of spectroscopic masses as a function of effective temperature for our complete sample. The stars below the dotted line are most likely binary systems since single white dwarfs with masses lower than $\sim0.47 M_\odot$ cannot have been produced within the lifetime of the Galaxy. They should also have a helium core.

3. UV Effective Temperature Determinations

Since the UV energy distribution is mostly independent of $\log g$, we constrain the $\log g$ value from the optical solution, and then use the UV spectrum to derive a temperature from two different methods. The first one relies on the slope of the energy distribution; here only relative fluxes are important and the effective temperature and the solid angle are considered free parameters. The second method, based on the approach of Finley et al. (1990), relies on the $V$ magnitude. Here, the model fluxes are normalized at $V$, and the measurement thus relies on the accuracy of the absolute UV fluxes and $V$ magnitudes. Depending on each star, one method could be preferable to the other, since there are instances when the IUE absolute fluxes are not reliable, or when the $V$ magnitude value is uncertain or suffers from contamination by a companion.

4. Results

The results of both methods are compared in Figure 2 as a function of distances, which are obtained from the optical value of $\log g$ —from which we derive $R$—combined with the UV solution for the solid angle $\pi(R/D)^2$. As can be seen, the two methods produce the same overall results. The dotted lines represent the $\pm10\%$ difference between optical and UV temperatures, which we consider as a conservative estimate of the uncertainties of the methods.

Our results first indicate that UV temperatures are generally underestimated with respect to optical temperatures for hot stars ($T_{\text{eff}}>40,000$ K) and for distant stars ($D>100$ pc; not shown here). This suggests that the presence of heavy elements in the atmosphere of hot stars, or the effect of interstellar red-
dening, or both, may play an important role in explaining our results. For the moment, however, we simply restrict our analysis to nearby objects ($D < 100$ pc) for which reddening is negligible. The optical and UV temperatures all agree within 10%, with the exception of the white dwarfs discussed in the next paragraph.

![Figure 2](image_url)

**Figure 2.** Differences between UV and optical temperatures for stars located within 100 pc using both methods for fitting the UV energy distributions. Within such a limit, reddening is assumed to be negligible.

Two DD systems are identified in this plot, WD 0135−052 (L870−2, EG 11) and WD 1022+050 (LP 550−52) discussed above and also shown in Figure 1. These are the only two known DD systems in this plot, both of which show discrepant optical and UV temperatures, indicating that our method works. The fact that only two such systems are identified here may not be surprising since DDs have been mostly discovered by surveying low mass DA stars, only two of which are found in our sample.

The remaining objects outside our 10% cutoff all have optical temperatures in excess of 40,000 K: WD 0346−011 (GD 50), WD 2111+498 (GD 394), and WD 0004+330 (GD 2). All have consistent $T_{\text{eff}}$ values when the $V$ normalization method is used, but discrepant values when the UV slope method is used. For WD 1819+580, the reverse is true. WD 0232+035 (Feige 24) has an M dwarf companion and all three temperature estimates may be uncertain. The last two objects, WD 0037+312 (GD 8) and WD 0621−376 exhibit quite different optical and UV temperatures, with both methods. These objects clearly deserve further investigation.

### 5. Simulations

Finally, it is instructive to simulate what results could be expected in the presence of DDs with arbitrary effective temperatures and surface gravities. To do
so, we first begin by co-adding two synthetic spectra with various values of $T_{\text{eff}}$ and $\log g$, properly weighted by their respective radii. The results are then analyzed with the optical spectroscopic and UV slope methods as if they were single stars. The results of our simulations are displayed in Figure 3 together with the results for our sample of 141 DA stars. It is important to note that the best fits do not necessarily represent good fits. For instance, the points above and below 40% would have been ruled out based on the quality of the solution (since both cool and hot optical solutions are considered here, below and above the maximum equivalent width near 13,000 K). Our results indicate that (1) double degenerate systems such as those simulated here do not exist in large numbers and (2) that the discrepant temperatures for the hot stars shown in Figure 2 cannot be explained in terms of binarity.

![Figure 3. Results of our simulations. Small dots are the simulated temperature differences of two coadded and fitted synthetic spectra with arbitrary effective temperature and surface gravity, while open circles are the estimated temperatures differences for our complete sample of stars.](image)

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