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White Dwarfs in the Capodimonte Deep Field

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Abstract. The goal of this project is to search for white dwarf (WD) candidates in the Capodimonte Deep Field (OACDF) photometric survey and confirm their nature through spectroscopy. In this contribution we discuss our selection criteria and present the spectra of two objects confirmed to be DA WDs (plus one misclassified object). Their spectra have been fitted with white dwarf models in order to determine their effective temperature and surface gravity.

1. Photometric Selection of White Dwarf Candidates

The Capodimonte Deep Field (OACDF) is a multi-band photometric survey covering 0.5 square degrees ($R \lesssim 25$) at high galactic latitude using the Wide Field Imager (WFI) attached to the ESO 2.2 m telescope at La Silla Observatory. From the original catalogs of the OACDF survey (see Alcalá et al. 2004 for more details), we first optimized the selection criteria to isolate the point-like sources using the parameter "flux radius" from SExtractor (Bertin & Arnouts 1996). This parameter is the aperture radius, in pixels, where 50% of the light is collected (1pix = 0.238 arcsec for WFI).

Figure 1 represents the "flux radius" versus magnitude plot, where the stellar branch can be easily identified. The six panels refer to the BVR bands in two adjacent WFI fields (OACDF2 and OACDF4). We can see that the contamination from extended objects starts typically near magnitude 21 for all the three bands, and becomes quite strong at mag 23 (or ∼24 in the B band). The selected objects are those falling inside the boxes indicated in Fig. 1. This criterion must be valid for the three photometric bands (BVR) simultaneously. In this way, we can exclude most of the extra-galactic contaminants and saturated stars that lie in the left upper part of each box.

In order to search for WD candidates, we compared the position of the point-like sources in the $B - V$ versus $R - V$ plane with the theoretical expectations from Bergeron, Wesemael, & Beauchamp (1995) – see Fig. 2. If we consider only the hottest objects ($B - V < 0.25$), there are about 20 WD candidates whose location is compatible with H or He WDs having an effective temperature higher

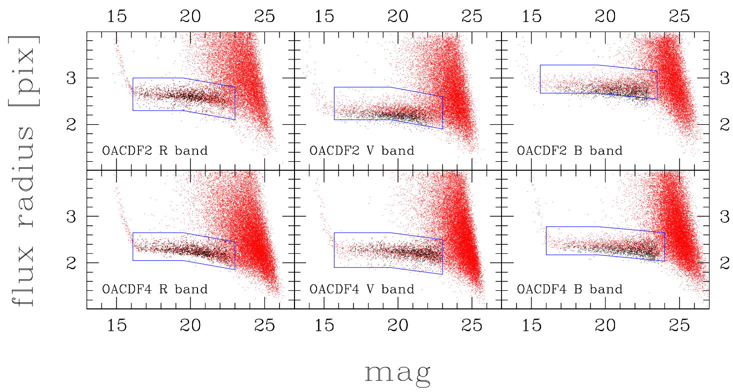

Figure 1. Selection of point-like sources from the two adjacent WFI fields (OACDF2 and OACDF4)

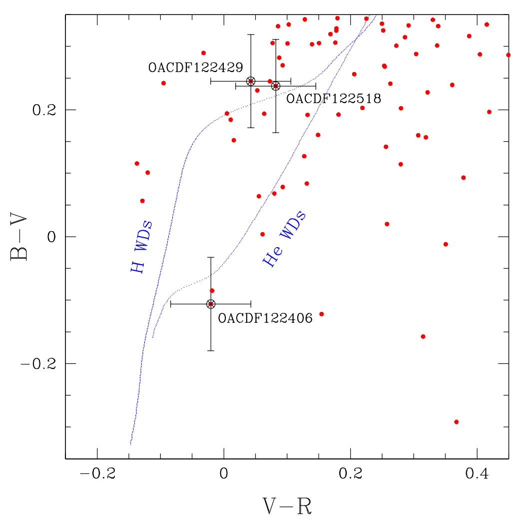

Figure 2. The $V-R$ and $B-V$ colors of the point-like sources compared with the theoretical tracks from Bergeron et al. (1995). The error bars represent the three WD candidates for which we have performed spectroscopic observations in order to confirm their nature – see Section 2.

than about 8500 K. For cooler WDs the selection is much more difficult because the contamination from main-sequence stars increases.

2. Spectroscopy

Among the WD candidates, three brighter stars, marked with a circle in Fig. 2, were selected to perform spectroscopic follow-up. In Table 1 we show the coordinates and photometry of these objects. The spectroscopic observations were carried out at La Silla observatory with EMMI at the NTT (OACDF122 429.3 and OACDF122 518.5) and with EFOSC spectrograph at the 3.6 m telescope

(OACDF122 406.4). The resolving power of the spectra was 5 Å and 15 Å for EMMI and EFOSC, respectively.

Table 1. Photometric information of the white dwarf candidates that we have studied

Name	RA	DEC	V	$B-V$	$V-R$
OACDF122 429.3−131413	12 24 29.3	−13 14 13	19.57	0.24±0.07	0.04±0.06
OACDF122 406.4−124855	12 24 06.4	−12 48 55	19.48	−0.11±0.07	−0.02±0.06
OACDF122 518.5−125607	12 25 18.5	−12 56 07	17.66	0.24±0.07	0.08±0.06

From these observations, the first two objects in Table 1 have been confirmed to be DA WDs and their spectra are shown in Fig. 3, left and right, respectively. The effective temperature ($T_{\rm eff}$) and surface gravity ($\log g$) of these stars were calculated by fitting the theoretical models of DA WDs by D. Koester (private communication) to the observed Balmer lines using the package SPECFIT under IRAF. This package is based on χ^2 minimization using the method of Levenberg-Marquardt (Press et al. 1992). Once we have $T_{\rm eff}$ and $\log g$ for each star, we derive its mass, $M_{\rm wd}$, and cooling time, $t_{\rm cool}$, using the cooling sequences of Salaris et al. (2000). Our results are shown in Table 2. The errors associated to the second target are probably underestimated due to the low resolution of the spectrum. Note that, even though the location of this object in Fig. 2 is compatible with a DB WD, its spectrum does not show any He line confirming its DA nature.

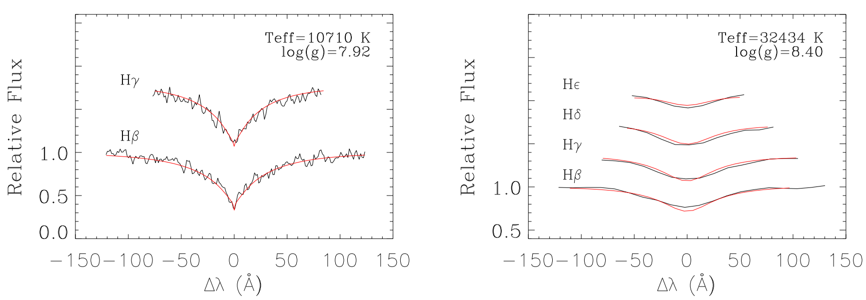

Figure 3. Model fits to the individual Balmer line profiles of the two DA WDs detected in this survey. In the right top of the figures, $T_{\rm eff}$ and $\log g$ of the best fit are indicated.

Table 2. Atmospheric parameters derived for the spectroscopically confirmed WDs

Name	$T_{\rm eff}$ (K)	$\log g$ (dex)	$M_{\rm wd}$ ($M_\odot$)	$t_{\rm cool}$ (Gyr)
OACDF122 429.3-131413	10710±300	7.92±0.05	0.56±0.02	0.44±0.04
OACDF122 406.4-124855	32434±1250	8.40±0.90	0.88±0.34	<0.13

For what concerns the third object, OACDF122 518.5, its colors are compatible both with a 8500 K WD and an A-type star. However, as we can see

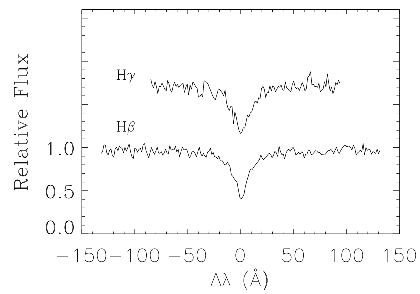

Figure 4. Relative flux versus wavelength, centered in each absorption line for the A-type star classified previously as a WD from photometry

from Fig. 4, the $H\beta$ and $H\gamma$ lines are narrower than typical WDs and therefore the A-type classification is more likely.

3. Future Work

This project was considered, since the beginning, as a test-program in order to be prepared for similar programs in larger multi-color surveys such as the Kilo-Degree Survey, KIDS (`http://www.strw.leidenuniv.nl/~kuijken/KIDS/`) and the Alhambra Survey (Moles et al. 2005), in which the authors of this paper are involved. In particular, with KIDS, the large coverage ($\geq$ 1500 sq. deg.) will allow to detect also peculiar objects such as the ultra-cool WDs, that can be well separated from main-sequence stars because of their unusual "blue" colors (Hansen 1998; Gates et al. 2004). On the other hand, the Alhambra Survey will cover 8 sq. deg. in 20 medium-band filters in the optical + JHK bands. Thanks to its depth ($V \simeq 25.5$) we expect to detect up to 300 WDs in this survey, 10 of them in the halo (Catalán et al. 2005).

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