Quasi-molecular satellites of Lyman β observed with ORFEUS

Nicole Allard[1]

Observatoire de Paris-Meudon, Département Atomes et Molécules en Astrophysique, 92195 Meudon Principal Cedex

Detlev Koester, Ulrich Sperhake, Stefan Jordan

Institut für Theoretische und Astrophysik, Universität Kiel, 24098 Kiel

David Finley

Eureka Scientific Inc., Oakland, CA

Abstract. The dependance of quasi-molecular satellites of Ly β on temperature and surface gravity is studied in ORFEUS observations of four DA. For the interpretation we use theoretical atmosphere models, which incorporate new profiles for Ly β including the variation of the transition probability with distance between emitter and perturber.

1. Introduction

Quasi-molecular features were first noted on the red wing of Ly α (Greenstein 1980). The theoretical description of these satellites and the successful application to the analysis of ZZ Ceti stars has been described in several recent papers (Allard & Koester 1992; Koester et al. 1994; Bergeron et al. 1995; Allard et al. 1998). In 1995, similar features were observed by HUT in the wing of Ly β at 1060 and 1078 Å, and interpreted quantitatively with the same theory (Koester et al. 1996). Here we report on an improvement of the theoretical description and on ORFEUS observations of the Ly β satellites in 4 DA.

2. New profile calculations

The new calculations by Allard et al. (1998) include the variation of the electric dipolemoment (and corresponding transition probability) with radiator-perturber distance instead of assuming the constant asymptotic value for very large distances. The only significant change resulting from the new calculations is stronger absorption near the satellites.

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[1]CNRS Institut d'Astrophysique, 98 bis Boulevard Arago, 75014 Paris

3. Observations and comparison with theory

Observations of the four DA white dwarfs were obtained in a guest observer project in Nov, Dec 1996 with the ORFEUS-SPAS II platform (wavelength range $\approx$ 900-1400 Å, resolution $\frac{\Delta\lambda}{\lambda} = 10^4$). Table 1 gives a list with the observed objects and observational and stellar parameters. For comparison, Wolf 1346 is included, which was not observed by ORFEUS but by HUT in 1995.

Table 1. Four DA white dwarfs observed with ORFEUS. $T_{\rm eff}$ and $\log g$ are from Finley et al. (1997). The final column gives the effective temperature of the best fit to the far UV spectra, holding $\log g$ fixed at the literature value.

WD	name	Obs. Date	Exp. time	$T_{\rm eff}$	$\log g$	$T_{\rm eff}$
WD0413-077	40 Eri B	Dec 2, 1996	1995	16490	7.77	16490
WD0644+375	He 3	Nov 22, 1996	4313	21000	8.04	21780
WD1031-114	L825-14	Nov 22-23, 1996	4133	24960	7.76	25390
WD1134+300	GD 140	Dec 3, 1996	4276	21030	8.41	22350
WD2032+248	Wolf 1346	HUT (Mar 1995)		19920	7.84	

Since the small wavelength range covered by ORFEUS is not suited for an independant determination of both $T_{\rm eff}$ and $\log g$, we have allowed $T_{\rm eff}$ to vary with $\log g$ fixed at the value of Table 1. Only for the HUT spectrum of Wolf 1346 we have used exactly the parameters of Finley et al. (1997). In Fig. 1, we compare the observations with theoretical models as well as the new and old profiles in enlargements of the satellite regions.

4. Results

As can be seen from the comparison in Fig. 1, the general agreement of the overall lineshapes in the region between the centers of Ly α and Ly β is good:

- The two prominent satellites at 1060 and 1078 Å are exactly at the predicted positions.
- In the hottest object, WD1031–114, at about 25000 K, the satellites are not visible any more at this S/N in accordance with theory.
- In the next two objects with similar $T_{\rm eff}$, the higher surface gravity of WD1134+300 causes broader wings of both, Ly α and Ly β, and a lower residual intensity at the satellites in complete agreement with theory.
- In the spectrum of 40 Eri B, the satellites are still very strong in observation and theory, but at slightly cooler temperatures, the absorption of Ly β and higher series lines will suppress the flux totally shortward of 1100 Å.

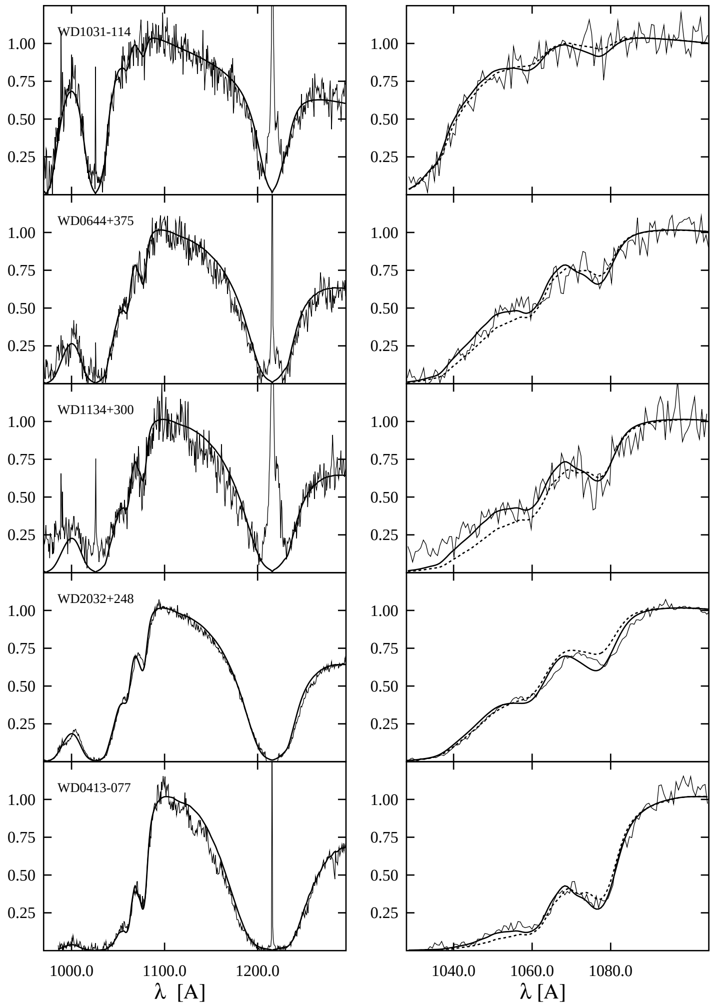

Figure 1. Comparison of observed spectra with theoretical models. The objects are ordered according to $T_{\rm eff}$ from top to bottom; the second object from the bottom is the HUT spectrum of Wolf 1346. The dotted lines in the right column are the best fits using the older profiles. The features between 1100 and 1160 Å in several ORFEUS spectra but not visible in the HUT spectrum are very likely artifacts of the reduction process in the overlapping range of echelle orders. On the other hand, a feature near 995 Å in WD1031–114 and WD0644+375 is also visible in the HUT spectrum and may be a new satellite in the wing of Ly γ.

- The enlargements of Fig. 1 show that the detailed agreement in the satellite region is good, though not perfect. The new profiles fit the line wings even better than the old calculations.
- The comparison for the HUT spectrum of Wolf 1346 shows that the far UV spectrum is very well fitted with parameters determined in a completely different wavelength range.

Acknowledgments. Work on ORFEUS observations in Kiel is supported by grants from the DLZ (Deutsches Zentrum für Luft- und Raumfahrt) under grant 50 QV 9703. We thank the Tübingen ORFEUS team for providing the instrument and especially Dr. J. Barnstedt for reducing the raw data for us.

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