KPD0005+5106:
Hottest DO White Dwarf Much Hotter Than Assumed

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Summary

KPD0005+5106 is the hottest known helium-rich white dwarf. We have identified Ne VIII lines in UV and optical spectra and conclude that it is significantly hotter than previously thought, namely T_{eff}=200 000 K instead of 120 000 K. We suggest that KPD0005+5106 is not a descendant of a PG1159 star but more probably related to the O(He) stars and RCrB stars.

Hot helium-rich white dwarfs

- The hottest He-rich WDs exhibit lines of ionized helium and they are classified as DO white dwarfs.
- Currently forty DOs are known. The coolest one has T_{eff}=40 000 K and the hottest one is KPD0005+5106.
- From an analysis of optical and HST/FOS spectra T_{eff}=120 000 K and log g=7 has been derived (Werner et al. 1994) for KPD0005+5106. The Sloan Survey has recently revealed another DO with T_{eff}=120 000 K (Hügelmeyer et al. 2006).

Identification of Ne VIII lines

- In the FUSE spectra of the hottest PG1159 stars (T_{eff}> 140 000 K) we have recently discovered absorption lines of Ne VIII (Werner et al. 2007). The same features were discovered in KPD0005+5106, too (Fig. 1, left panel).
- Emission lines in the optical spectra are also from Ne VIII and not, as previously thought, from superionized (i.e., non-thermally excited) O VIII (Figs. 1 and 2, right panels).
- Non-LTE line profile fits to the Ne VIII lines of KPD0005+5106 yield T_{eff}=200 000 K and log g=6.5.
- A reassessment of the He II line spectrum confirms these parameters (Fig. 3). Hence, KPD0005+5106 is by far the hottest He-rich WD.

X-ray emission

- ROSAT has revealed two X-ray emission components of KPD0005+5106. Chandra observations of the soft component (20–80 Å) proof that is of photospheric origin (Drake & Werner 2005) and not, as claimed, coronal (Fleming et al. 1993). Deposing the idea of non-photospheric O VIII lines is in accordance with the deposition of the corona.
- The hard component (at 12 Å) remained unexplained (O'Dwyer et al. 2003). In the light of the newly determined, extreme T_{eff} it should be investigated whether this component is of photospheric origin, too.

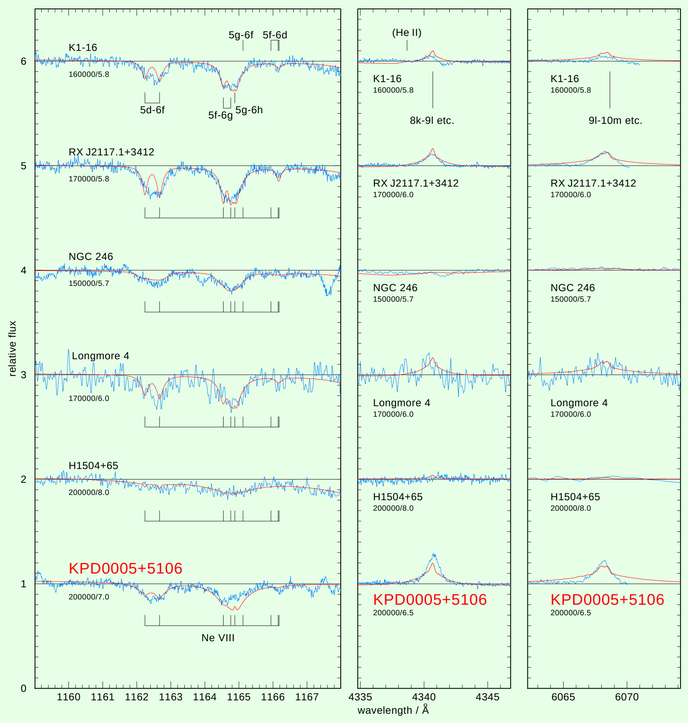

Fig. 1. Left panel: Identification of Ne VIII lines in the FUSE spectra of PG1159 stars and KPD0005+5106. Several lines of the $n = 5 \rightarrow 6$ transition are detected as labeled in detail at the uppermost spectrum. Overplotted are computed profiles with T_{eff} and log g as indicated. Middle and right panels: Optical spectral regions where we identified the Ne VIII $n = 8 \rightarrow 9$ and $n = 9 \rightarrow 10$ transitions.

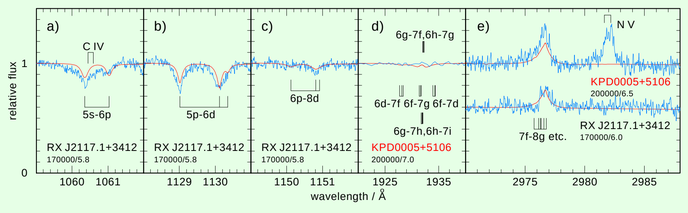

Fig. 2. Details of other spectral regions of the PG1159-type central star RX J2117.1+3412 and the DO white dwarf KPD0005+5106 displaying Ne VIII lines. Panels a)–c) show $n = 5 \rightarrow 6$ and $n = 6 \rightarrow 8$ transitions (the blending C IV line in panel a) is not included in the model). Panel d) shows a barely detectable $n = 6 \rightarrow 7$ emission feature in the HST/FOS spectrum of KPD0005+5106 which was previously assigned to O VIII. Panel e) displays HST/GHRS spectra with a Ne VIII $n = 7 \rightarrow 8$ emission line that was also thought to stem from O VIII. The adjacent emission feature in KPD0005+5106 is from nitrogen; it is not included in the model.

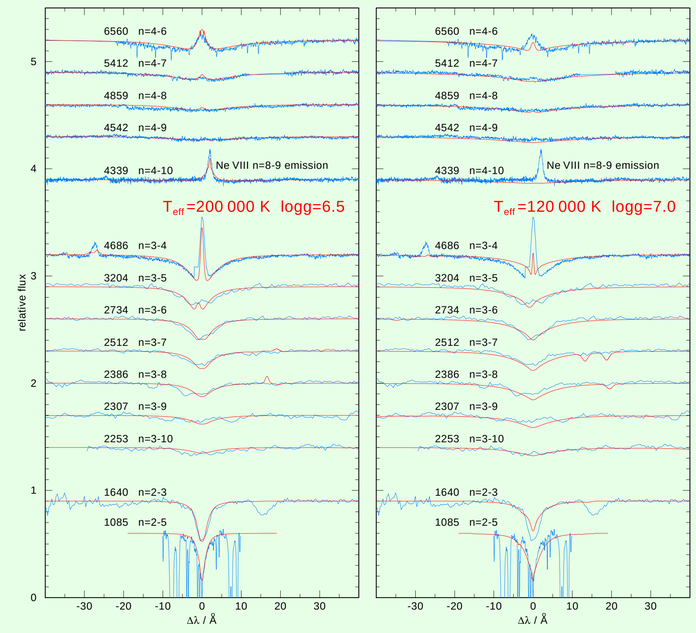

Fig. 3. The He II lines in KPD0005+5106 are compared with two different models. Left panel: T_{eff}=200 000 K, log g=6.5. Right panel: T_{eff}=120 000 K, log g=7.0. The hotter model yields a much better fit. In particular, only this model matches the emission cores in the $\lambda\lambda$ 6560 and 4686 Å lines. The emission line at λ 4340 Å is due to Ne VIII and is only exhibited in the hotter model.

Evolutionary status

- KPD0005+5106 is located on a $0.7\,M_{\odot}$ Wood & Faulkner (1986) post-AGB track, just before the "knee", at the hot end of the WD cooling track.
- KPD0005+5106 is well within the PG1159 domain of the HRD, hence, it cannot simply be a PG1159 descendant.
- The immediate progenitor could have been a O(He) star. This spectral class consists of four hot stars (T_{eff}=100 000–140 000 K, log g=5.5–6.5, Rauch et al. 1998) with almost pure He atmospheres. KPD0005+5106 and the O(He) stars might be descendants of RCrB stars.

References

Drake, J. J., & Werner, K. 2005, ApJ, 625, 973
Fleming, T. A., Werner, K., & Barstow, M. A. 1993, ApJ, 416, L79
Hügelmeyer, S. D., Dreizler, S., Homeier, D., et al. 2006, A&A, 454, 617
O'Dwyer, I. J., Chu, Y.-H., Gruendl, R. A., et al. 2003, AJ, 125, 2239
Rauch, T., Dreizler, S., & Wolff, B. 1998, A&A, 338, 651
Werner, K., Heber, U., & Fleming, T. A. 1994, A&A, 284, 907
Werner, K., Rauch, T., & Kruk, J. W. 2007, A&A, in press
Wood, P. R., & Faulkner, D.J. 1986, ApJ, 307, 659

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Please take a copy of the poster and a copy of the paper on the discovery of Ne VIII lines (A&A in press)

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