Stellar Rotation
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The Rotational Velocity of Helium-rich Pre-White Dwarfs

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Abstract. Previous investigations on hydrogen-rich white dwarfs generally yield only very small rotational velocities ($v \sin i$). We have analyzed line profiles in high-resolution optical spectra of eight hydrogen-deficient (pre-) white dwarfs and find deviations from the dominant Stark line broadening in five cases which, interpreted as an effect of stellar rotation, indicate projected rotational velocities of $40 - 70$ km s^{-1}. For the three least luminous stars upper limits of $v \sin i = 15 - 25$ km s^{-1} could be derived only. The resulting velocities correlate with luminosity and mass. However, since the mass-loss rate is correlated to the luminosity of a star, the observed line profiles may be affected by a stellar wind as well. In the case of RX J2117.1+3412, this would solve discrepancies to results of pulsational modeling ($v \sin i \approx 0$).

Detailed analyses of the NLTE Balmer line cores of DA white dwarfs have revealed that for the vast majority the rotational velocities are extremely low, so that they cannot be detected, even with high-resolution high-S/N spectra (Heber et al. 1997, Koester et al. 1998). This unexpected behavior poses the question how these WDs have lost their angular momentum during previous evolutionary phases. To our best knowledge no one has ever tried a similar analysis on non-DA white dwarfs or hydrogen-deficient pre-white dwarfs. The only exception is the PG 1159-type central star of NGC 246, whose high rotational rate is well known since many years (Heap 1975, Rauch & Werner 1997). High-resolution optical (HIRES at KECK, EMMI at ESO NTT) spectra of PG 1159 stars can in principle be used to resolve the narrow line cores (in absorption or emission) of He II, C IV, and O VI and to constrain the rotational velocity.

Synthetic spectra of NLTE model atmospheres (see Werner et al. 1997 for parameters and references) have been convolved with rotational profiles in order to compare them to the observation. Different lines have been evaluated for the determination of the rotational velocity. The adopted $v \sin i$ are summarized in Fig. 1. However, we are aware of some problems (Köper et al. 2001).

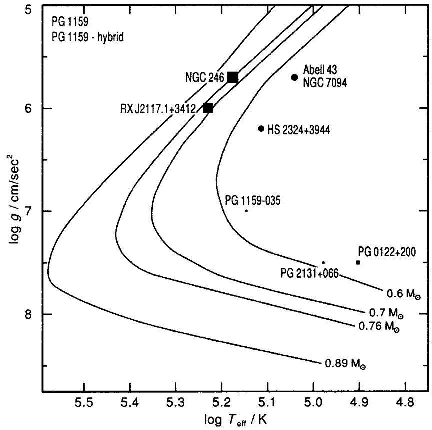

Fig. 1. Position of our programme stars in the $\log T_{\rm eff} - \log g$ plane compared to evolutionary tracks of helium-burning post-AGB stars (Wood & Faulkner 1986, labeled by the stellar mass). The symbol's size is equivalent to $v \sin i$ of the star:

PG 1159−035	< 15		km $\rm s^{-1}$
PG 2131+066	< 15		km $\rm s^{-1}$
PG 0122+200	< 25		km $\rm s^{-1}$
Abell 43	42	± 13	km $\rm s^{-1}$
HS 2324+3944	42	$^{+28}_{-12}$	km $\rm s^{-1}$
NGC 7094	46	± 16	km $\rm s^{-1}$
RX J2117.1+3412	68	$^{+14}_{-18}$	km $\rm s^{-1}$
NGC 246	77	$^{+23}_{-17}$	km $\rm s^{-1}$

All five low-gravity (i.e. high-luminosity) PG 1159 stars show deviations from synthetic "Stark-broadened" line profiles in the observed line cores. This suggests that the more massive of these have higher rotational velocities (Fig. 1). However, the rapid rotation of RX J2117.1+3412 ($v_{\rm rot} \sin i = 68$ kms^{-1}) is in contradiction to the asteroseismology results of Vauclair et al. (2002). They found $v_{\rm rot} \sin i < 0.5$ kms^{-1}. Although most of their parameters derived from the pulsational modeling, e.g. $T_{\rm eff}$, mass, distance, and luminosity, are in disagreement with results from spectral analysis (Rauch & Werner 1997), this may be a hint for an influence of the stellar wind on the observed line profiles, i.e. the measured line profiles may be affected by an additional turbulence broadening in the wind of this relatively luminous star. The fast "rotation" of NGC 246 may then be explained by wind effects as well. The slow rotation of PG 1159-035, deduced from asteroseismology (Winget et al. 1991), is corroborated. Silvotti et al. (1999) presented an asteroseismology study of HS 2324+3944 but they could not achieve sufficient precision in their results.

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