MCA1B - A DORMANT LBV IN M33?

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Abstract. A detailed study of the Ofpe/WN9 candidate MCA1b in M33 (Willis *et al.* 1992) is presented, based on new high-resolution observations. We re-classify MCA1b as WN9-10 and determine its physical parameters ($T_* = 29$ kK, $\log L/L_\odot = 5.9$, $\log \dot{M} = -4.0$, $v_\infty = 420$ km s^{-1}) and composition (H/He = 2.6, N/He = 0.003, C/N = 0.2) using the Wolf-Rayet standard model. Overall, MCA1b is very similar to the LMC stars R84 (WN9, Crowther *et al.* 1994) and R71 (LBV, Lennon *et al.* 1994) indicating a similar evolutionary status and metallicity.

Key words: stars: atmospheres – Wolf-Rayet – abundances – winds – mass-loss

1. Introduction

The study of hot, luminous stars in galaxies allows the investigation of stellar evolution and mass loss in different environments. One such group are the Ofpe/WN9 stars which have apparently composite Ofpe (photospheric He II) and WN9 (N II emission) features (Bohannan & Walborn 1989; Crowther *et al.* 1994, Paper I). Until recently these stars were exclusive to the LMC, although Allen *et al.* (1990) observed stars with similar IR properties at the Galactic Centre, and Willis *et al.* (1992) discovered another candidate, MCA1b, in M33, which is the subject of the present study.

2. Observations, analysis and evolutionary implications

Our technique uses the Wolf-Rayet standard model (Hillier 1990) to determine the physical and chemical properties of MCA1b, and follows the method outlined in Paper I. Our analysis is based on new high-resolution WHT-ISIS observations covering 3800–7000Å. We re-classify MCA1b as WN9-10 since He II λ4542, λ5411 are wind features, following a similar revision to the LMC Ofpe/WN9 stars in Paper I. This avoids the implication that these stars are at an evolutionary phase intermediate between Ofpe and WN9. The derived stellar parameters and chemistry for MCA1b are presented in Table I and compared with two LMC WN9-10 stars. We find that MCA1b has very similar physical properties to R84 although MCA1b has a higher mass loss rate, and is slightly more luminous (see also Fig. 1). In Paper I, it was concluded that R84 was either a dormant Luminous Blue Variable (LBV) or at a phase immediately after this stage. Since the chemistry of MCA1b is also very similar to R84 an identical evolutionary status

K. A. van der Hucht and P. M. Williams (eds.), Wolf-Rayet Stars: Binaries, Colliding Winds, Evolution, 331–332.

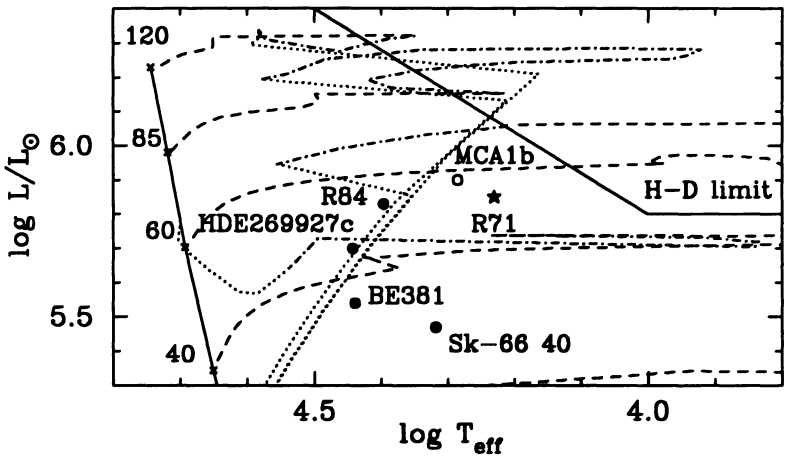

Fig. 1. Location of MCA1b on the HR diagram (open circle) compared to the evolutionary tracks of Meynet *et al.* (1994) for $Z = 0.008$ indicated by dashed ('pre-WNL'), dot-dashed ('WNL'), dotted ('post-WNL') lines, allowing estimates of the initial and present mass of MCA1b ($\simeq 50 M_\odot$ and 25 $M_\odot$). Four LMC WN9-10 stars from Paper I (filled-in circles) and R71 at minimum (filled-in star) from Lennon *et al.* (1994) are also shown.

TABLE I

Comparison of physical parameters of MCA1b with two LMC WN9-10 stars from Paper I.

star	WN	log T_*	log $T_{\rm eff}$	$R_{2/3}$	log L	log $\dot{M}$	v_∞	H/He	N/He	C/N	M_V
R84	9	4.45	4.40	44.2	5.83	−4.40	400	2.4	0.003	0.03	−7.0
MCA1b	9–10	4.46	4.28	79.3	5.90	−3.98	420	2.6	0.003	0.13	−7.2
Sk-66° 40	10	4.46	4.32	41.9	5.47	−4.47	300	3.5	0.002	0.30	−6.2

and metallicity ($Z \sim 0.01$) is implied for MCA1b. Indeed, MCA1b is also chemically and physically very similar to the LBV R71 (Lennon *et al.* 1994). Finally, we note that nebular [N II] lines are observed in MCA1b, analogous to those seen in some LMC Ofpe/WN9 stars (Walborn 1982).

References

Allen, D.A., Hyland, A.R., Hillier, D.J. 1990, *MNRAS* **244**, 706
Bohannan, B., Walborn, N.R. 1989, *PASP* **101**, 639
Crowther, P.A., Hillier, D.J., Smith, L.J. 1994, *A&A* in press (Paper I)
Hillier, D.J. 1990, *A&A* **231**, 116
Lennon, D.J., Wobig, D., Kudritzki, R.P., Stahl, O. 1994, *Sp. Sci. Rev.* **66**, 207
Meynet, G., Maeder, A., Schaller, G., Schaerer, D., Charbonnel, C. 1994, *A&A Suppl.* **103**, 97
Walborn, N.R. 1982, *ApJ* **256**, 452
Willis, A.J., Schild, H., Smith, L.J. 1992, *A&A* **261**, 419