NEW MODELS FOR WOLF-RAYET STARS: GLOBAL DIFFUSION

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Abstract. We present a scenario for the evolution of massive stars in which a new mixing mechanism (named global diffusion) is taken into account. This type of mixing stands on the critical Reynolds number and radiative viscosity (Schatzman 1977) and allows mixing of material to take place between the core and the surface during the whole evolution on a very slow time scale. The physical processes triggering global diffusion deserve further study. We find that stellar models of massive stars calculated with global diffusion offer interesting clues to understanding the properties of Wolf-Rayet stars and their location in the HRD.

Key words: stars: Wolf-Rayet – evolution – mixing processes

Two sets of stellar models computed with the new scheme of mixing are presented. The physical gradients of the models is the same as Bressan *et al.* (1993), while the mixing mechanism and other details of the models can be found in Deng (1994) and Deng *et al.* (1994). The stellar tracks are given in Fig. 1, which shows a very good fit to the observation of Hamann *et al.*

TABLE I
Theoretical lifetime ratios for the WR sequences

Z	$M/M_\odot$	t_H	t_{He}/t_H	WR/OB	WNE/WNL	WN/WR
0.020	9	1.77	0.026	0.028	3.208	0.337
	12	1.21	0.032	0.034	1.905	0.282
	15	1.02	0.041	0.045	1.099	0.232
	20	0.86	0.054	0.061	0.475	0.194
	25	0.78	0.067	0.082	0.186	0.176
	30	0.81	0.087	0.109	0.150	0.185
	40	0.69	0.099	0.154	0.019	0.338
0.008	12	0.85	0.022	0.026	0.841	0.509
	15	0.71	0.028	0.042	0.382	0.391
	20	0.61	0.038	0.073	0.143	0.537
	25	0.57	0.047	0.073	0.023	0.408
	40	0.51	0.066	0.148	0.001	0.521

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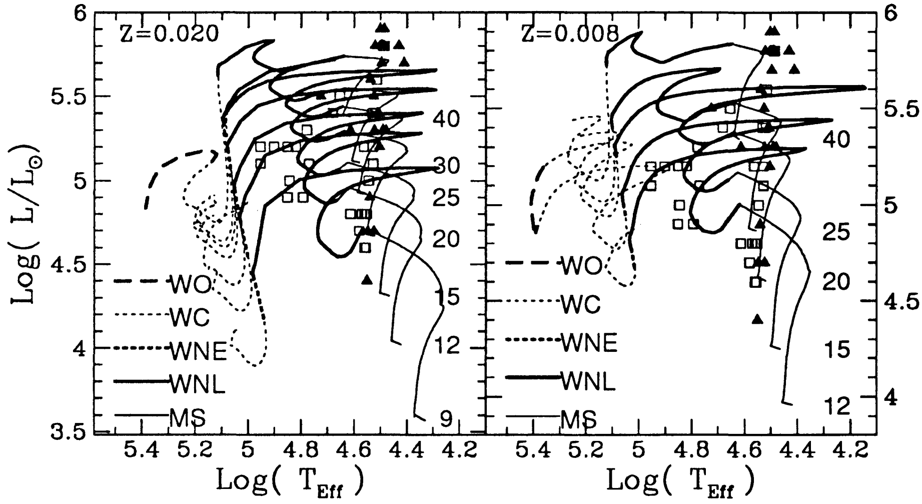

Fig. 1. Evolutionary tracks with global diffusion, superposed on data of Hamann *et al.* (1993) for single galactic WN stars. Solid triangles show WN stars with surface hydrogen; open squares show hydrogen-free objects.

(1993), especially the low luminosity WNLs, which cannot be explained with the standard models according to Maeder (these proceedings). The life-time data for the sequences are given in Table I.

We find the following properties of WR stars: (1) The formation of WR stars is possible at much lower values of the initial mass (therefore much lower luminosity) than with standard models (*cf.* Schaller *et al.* 1992). The initial mass above which the WR phase starts is $\sim$ 10 $M_\odot$, this eventually alleviates the discrepancy between the expected and the observed positions of WR stars in the HRD, in particular for the less luminous ones. No *ad hoc* assumptions for the rates of mass loss are needed. (2) However, global diffusion does not bear very much on the evolution of the most massive stars, say above 30-40 $M_\odot$, as it is overwhelmed by the dominant effect of mass loss. (3) Finally, there is a lower limit below which global diffusion does not alter the classical evolutionary path in the HRD and therefore does not lead to the formation of a WR object.

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