EVOLUTION OF THE PRECURSOR OF SN1987A

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The evolution of a 17.5 $M_\odot$ star, chosen to be similar to the precursor of SN1987A, has been studied using the input physics described in Wood and Faulkner (1987). The calculations: use opacities from the *Astrophysical Opacity Library* of Huebner *et al* (1977) with H, He, C, N, O and other metals in LMC ratios; treat semi-convection in the manner of Lamb, Iben and Howard (1976); and assume the mass loss rate to be the minimum of (a) α times the rate give in Waldron (1985) (this rate applied in the blue part of the HR diagram), and (b) $L/(c\nu)$ (this rate applied in the red), where ν is the stellar wind expansion velocity which was taken to be 12 km s^{-1}.

Typical evolutionary tracks resulting from these calculations are shown in Figure 1. The track shown as a continuous line is the one shown in Wood and Faulkner (1987) and corresponds to α = 2.5, while the track shown as a dotted line results from a slightly different treatment of semi-convection on the main-sequence and to α = 1.

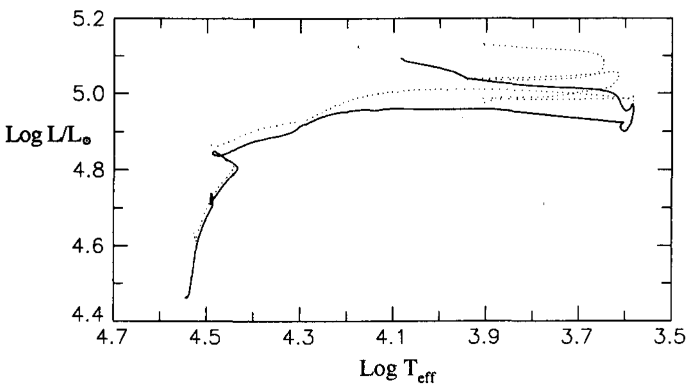

Figure 1. Evolution of a 17.5$M_\odot$ star for two different treatments of the input physics.

From these tracks, and a number of others which we have computed, we find the following.

(1) During the main-sequence phase, the star has a shrinking fully convective core surrounded by a semi-convective zone; once only, a fully convective region in the semi-convective zone makes contact with the central convective zone, causing an increase in the central hydrogen abundance and giving rise to the brief loop seen during the main-sequence phase. At the end of the main-sequence phase, a fully convective zone develops outside the core and mixes the former semi-convection zone. The resultant helium abundance profile is shown in Figure 2; this profile has a strong effect on subsequent evolution.

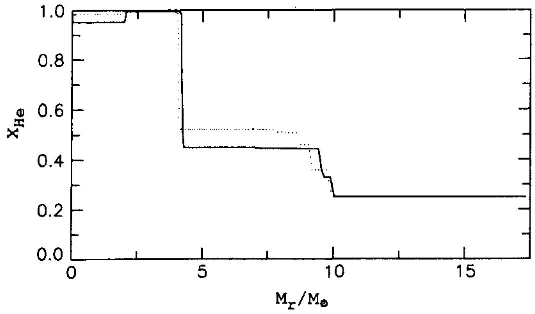

Figure 2. The helium abundance profile left at the end of the main-sequence phase for the two sequences in Fig. 1.

(2) The star always begins helium core burning in the blue (log $T_{eff} \approx 4.3$) but *always* evolves to the red supergiant domain some time during core helium burning.

(3) The star *always* makes a final trip back to the blue and undergoes a supernova explosion when the hydrogen envelope is reduced to a few tenths of a solar mass (assuming sufficient mass loss has occurred). Final mass is ~5.5$M_\odot$.

(4) The details of the intervening evolution are sensitive to the choice of convective mixing on the main-sequence and mass loss. Two blue loops may occur (a) when mass loss reveals the material of high helium content within ~10 $M_\odot$ of the stellar centre, and (b) when the hydrogen envelope is reduced to ~0.6 $M_\odot$ while the hydrogen shell is still active (when the H shell is extinguished by further mass loss the star takes a final trip to the red). Figure 3 shows time variation of some stellar properties.

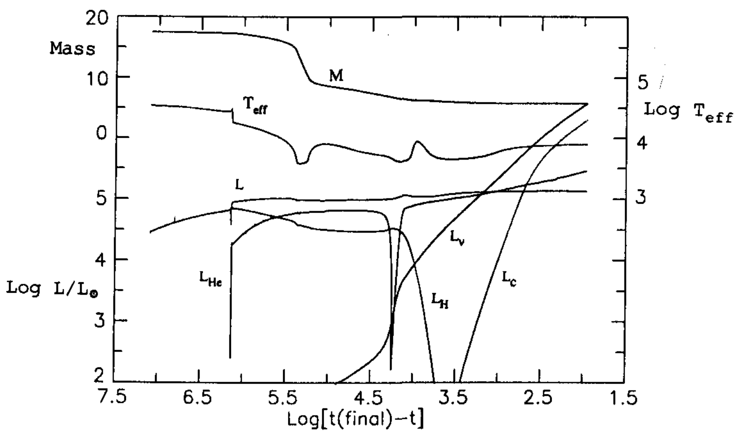

Figure 3. Time dependence along the model sequence shown as a dotted line in Figs. 1 and 2.

References

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