THE EVOLUTION OF THE PRECURSOR OF SN 1987 A

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SUMMARY

Ideally, the evolutionary models for the precursor of SN 1987 A should account for both the SN properties and the observational constraints for massive stars with relevant mass and composition.

Mass loss is an essential property of massive star evolution [1]. Recent parametrisations of mass loss rates $\dot{M}$ for galactic stars cover the whole HR diagram [2]. There are indications [3,4] that for given L and Teff values, $\dot{M}$ is lower at lower metallicity and therefore $\dot{M}$ is lower in the LMC than in the Galaxy, thus we take $\dot{M}_{LMC} = f \cdot \dot{M}_{Galaxy}$ with $f < 1$. Various models of an intitial 20 $M_\odot$ star with f=0.2, 0.4, 0.6 and 1.0 are constructed (cf. Fig. 1) with a metallicity

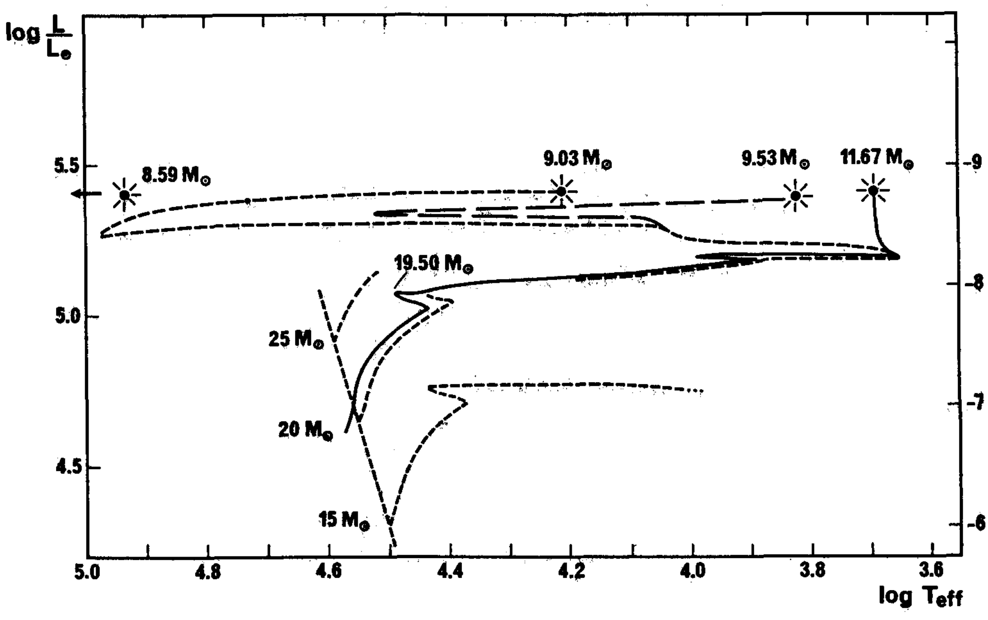

Fig.1 : Evolutionary tracks in the HR diagram for a model with an intial mass of 20 $M_\odot$ and composition X=0.744 and Z=0.006. Various cases of mass loss in post-MS evolution are considered and the remaining final masses are indicated.

Z=0.006 and a moderate overshooting d_{over}=0.3 H_p. From these models, we suggest an initial mass on the zero age sequence of 17 to 18 $M_\odot$. The pre-SN location in the HR diagram very much depends on the remaining stellar mass, or more precisely on the mass of the remaining H-rich envelope. A final location at log Teff $\simeq$ 4.2 is obtained for a final mass of about 9.0 $M_\odot$ (cf. Fig.1). Scaled to an initial value of 17 $M_\odot$, this corresponds to a final mass of about 8 $M_\odot$ and a remaining H-rich envelope of a few tenths of a solar mass at most. The stellar surface exhibits CNO equilibrium values with C/N $\simeq$ 0.01 and O/N $\simeq$ 0.1 in mass fraction, and an hydrogen content X (surf) = 0.39. The blue progenitor is obtained for f=0.4, i.e. for $\dot{M}$-values in the LMC equal to 40% of the galactic values.

The models must also account for the frequency of red supergiants (RSG). The observations [5] suggest the following lifetime ratios t_{RSG}/t_{tot} : 0.12 in the SMC, 0.08 in the LMC, 0.08 and 0.02 for the outer and inner galactic regions. As to the models, they indicate [1] the following relation : $\dot{M} \nearrow \Rightarrow t_{RSG}/t_{tot} \frown\!\!\searrow$. Since $\dot{M}$ is likely to increase along the sequence of the 4 galactic sites considered, the above observed lifetime ratios imply that the various considered galactic sites are located in the part of this last relation, where t_{RSG}/t_{tot} is decreasing with increasing $\dot{M}$. Such a behaviour implies the existence of a substantial mass loss, even in the SMC and LMC. Interestingly enough, the observed lifetime ratio of 8% for the LMC is also reached for an f value of 0.40. Thus, the same model is able to simultaneously account for the blue SN precursor and for the observed RSG frequency as well as for the existing evidences of CNO processing in the spectrum of SN 1987 A [6,7].

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