STELLAR EVOLUTION WITH SMC CHEMICAL ABUNDANCES

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Evolutionary computations are presented for massive stars between 20 $M_{\odot}$ and 100 $M_{\odot}$ with chemical abundances holding for the Small Magellanic Cloud, i.e. X = .76 and Z = .003. Mass loss by stellar wind is taken into account during core hydrogen burning. After core hydrogen burning some models are considered as members of close binary systems and are followed during their Roche lobe overflow stage according an early case B of mass transfer. During the core helium burning stage of the RLOF remnants mass loss rates comparable to WR stars are included in order to study the formation and the evolution of WR stars. Comparison with similar galactic computations (Vanbeveren, Packet, 1978) is made.

1. CORE HYDROGEN BURNING

We used the mass loss rate formalism of de Loore et al. (1977, 1978), i.e.

$$\dot{M} = -NL/c^2$$

In order to make direct comparison with galactic models possible the traditional values of N (=0,100,300 and 500) were considered. The comparison revealed that the luminosity in SMC models is 5 to 10% higher at the zero age main sequence than in corresponding galactic models. At redpoint the difference is less than 5%. The effective temperatures in the SMC computations are about 10% higher. This results in a shift of the main sequence band to the blue by about one subclass. This is shown in Figure 1. The stellar radii are 20 to 30% smaller at ZAMS and 20% at redpoint.
Central temperatures are 10% higher, and central densities 30 to 40% higher in the SMC. This effect causes a shortening of the hydrogen main sequence lifetime and thus a faster nuclear burning occurs. In the SMC, this shortening is largely compensated by a larger amount of hydrogen (X_{init} = .76); it follows that the MS-lifetime is about 10 to 15% larger in the SMC than in the Galaxy. Furthermore the behaviour of the convective core, the MS end mass, the mass-luminosity relation, the $\dot{M}$ rates for equal values of N differ by less than 10% from galactic results.

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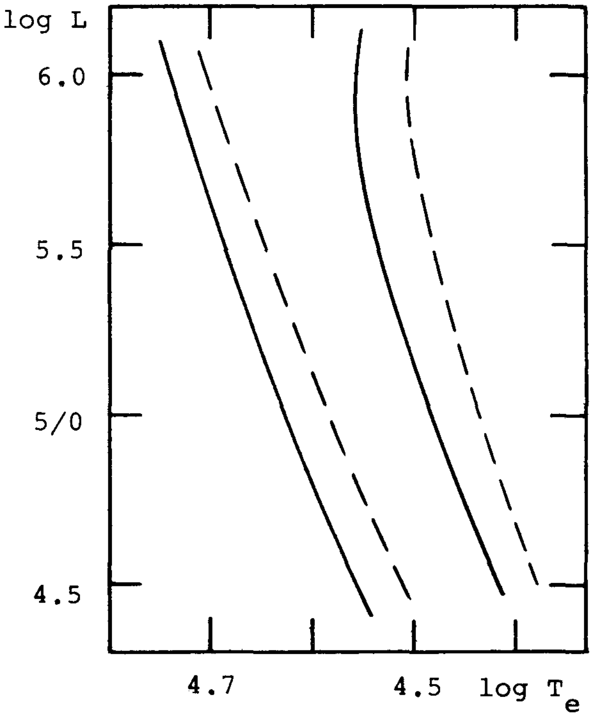

Figure 1. The position in the HR diagram of ZAMS and end of core hydrogen burning models for the Galaxy (dashed lines) are compared to the SMC (full lines).

2. CLOSE BINARY EVOLUTION AND RLOF-REMNANTS

Close binary evolution according an early case B of mass transfer was computed for stars with initial masses equal to 30 M_O (N=300), 60 M_O (N=0) and 100 M_O (N=300). The Roche lobe overflow stops as a consequence of core helium ignition which happens when $X_{atm} \simeq .20$ at the end of Roche lobe overflow (Vanbeveren, De Grève (1979). The remnants were followed up to core helium exhaustion similarly as has been done for the Galaxy (Vanbeveren, Packet, 1978).

Further mass loss by stellar wind stripps off the remaining hydrogen layers and pure He+ metal layers appear at the surface. Further mass loss may bring carbon enhanced layers from the original convective helium burning core in the atmosphere. This stage corresponds to WC stars. Table 1 gives evolutionary parameters during RLOF and during stationary He-burning. For the latter phase various values for $\dot{M}$ were considered.

Comparison with galactic computations (Vanbeveren, Packet, 1978) reveals almost no difference between the Galaxy and the SMC. Therefore only the change of initial chemical composition cannot explain the difference between the observed WN/WC ratios in the Galaxy and the SMC.

Table 1. Evolutionary parameters of SMC close binaries

M_I		M_e		M_g		M_{He}		$\dot{M}$ He-burning
60	(N=0)	60	(RLOF)	26.4	(N=500)	19.4	WN	$2\ 10^{-5}$
					(N=1000)	15.9	WC	$3\ 10^{-5}$
					(N=3000)	5.8	WC	$7\ 10^{-5}$
100	(N=300)	45.0	(RLOF)	32.8	(N=500)	25.5	WN	$3\ 10^{-5}$
					(N=1000)	19.9	WC	$5\ 10^{-5}$
					(N=3000)	6.3	WC	$10\ 10^{-5}$
30	(N=300)	18.1	(RLOF)	7.3	(N=800)	6.0	WN	$.3\ 10^{-5}$
					(N=1000)	5.0	WN	$.5\ 10^{-5}$

Obviously the chemical composition may influence the N-values, the N-values being smaller in the SMC than in the Galaxy.

REFERENCES

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DISCUSSION

LAMERS: In comparing the evolutionary tracks for galactic and SMC sources, I suppose that you compared tracks with the same value of the mass loss rates or N. In fact, the mass loss rates in the SMC may be smaller than in the galaxy, which implies that one would have to compare galactic tracks with SMC tracks of lower N.

HELLINGS: We wanted to investigate whether just the change of the initial chemical abundances can imply differences between the galaxy and the SMC. Therefore, we compared galactic models and SMC-models with the same mass and the same value for N.

NIEMELA: You know that there are otherwise normal looking OB stars with enhanced C in their spectra, the so-called OBC stars. Now, could they fit in these evolutionary tracks?

VANBEVEREN: They don't fit at all.

VANBEVEREN: From an evolutionary point of view one expects that the CNO surface abundances in WN stars of the galaxy are larger by a factor 10 compared to WN stars in the SMC. Are there any indication from observations that this is true?

CONTI: What is chemical composition in SMC?

McNAMARA: The SMC-spectra of Cepheids indicate only relatively small metal deficiency relative to galactic Cepheids. The m_1 index, on the other hand, indicates $[Fe/H] \sim -1.2$.

MOFFAT: I understand your atmosphere calculations are rather crude. In the case of the He core burning stars can you then be sure that you can recognize when the WN phase or the WC phase really begins? (Does convection extend right from the surface from where we observe the WR phenomenon to near the burning core where N/H or C/H are enriched ?)

VANBEVEREN: What we know from evolutionary computations is the variation of the atmospherical abundance of X, Y, C, N, O, the luminosity, the mass, and that is all. A finer subdivision is not possible with the present evolutionary code. The treatment of the atmosphere is too rough for example to distinguish between the subtypes of WN or WC types.

MENDEZ: I would like to remark that there is at least one OBC star (HD 141969) which is the central star of a planetary nebula (He 2-138). Therefore, the OBC phenomenon can appear both in high-and low-mass stars in the same way as the WC phenomenon.

BISIACCHI: I would like to make a comment on the origin of the ON stars To solve this problem, we must take into account that many of these stars are high above the galactic plane. In a sample of 120 O stars we have also found that the fraction of ON stars outside of the association is of the order of .64 compared with the fraction of .1 that is accepted for the total sample of the O stars.