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The Carbon Star Luminosity Functions in the Magellanic Clouds

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Abstract. We address the question of reproducing the observed luminosity functions of carbon stars (CSLF) in both the LMC and SMC, characterized by quite different features (i.e., faint end and peak location), using a new formalism for the third dredge-up in TP-AGB models.

The formation of single carbon stars is usually ascribed to the third dredge-up at thermal pulses in AGB stars. Complete evolutionary models are still affected by a large degree of uncertainty in describing this process, and in general fail to describe the formation of faint low-mass carbon stars. In this context, synthetic TP-AGB models can provide useful indications.

Marigo et al. (1996, 1998) and Marigo (1998) developed an updated semi-analytical code to describe the evolution of TP-AGB stars. In the latter models, the dredge-up is described by means of two parameters: (1) the efficiency parameter $\lambda = \frac{\Delta M_{\rm dred}}{\Delta M_{\rm c}}$, defined as the fraction of the core mass increment over an inter-flash period which is dredged-up to the surface at the subsequent thermal pulse; (2) the temperature parameter $T_{\rm b}^{\rm dred}$, expressing the minimum value of temperature at the base of the convective envelope for the occurrence of dredge-up at the stage of the post-flash luminosity maximum.

If λ is of common use in synthetic TP-AGB models (e.g. Groenewegen & de Jong 1993; Marigo et al. 1996), the introduction of $T_{\rm b}^{\rm dred}$ represents an improvement, as it allows us to infer the dependence of the minimum core mass for dredge-up to occur in M and Z. Moreover, no ad hoc assumption is then needed to determine when the dredge-up stops in the final stages of AGB evolution.

The models couple analytical relations derived from detailed full AGB models (Wagenhuber & Groenewegen 1998) and integrations through the complete envelope relying on the most recent input physics. They account for the occurrence of hot-bottom burning in the most massive TP-AGB stars ($M > 3.5 M_{\odot}$), and the possible break-down of the $M_{\rm c} - L$ relation (see Marigo 1998). The adopted mass-loss prescription is that by Vassiliadis & Wood (1993).

The formation of carbon stars is investigated with the aid of these models. The dredge-up parameters λ and $T_{\rm b}^{\rm dred}$ are determined by demanding that the theoretical luminosity functions of carbon stars, calculated for initial metallicity $Z = 0.008$ and $Z = 0.004$, suitably fit the distributions observed in the LMC and SMC, respectively.

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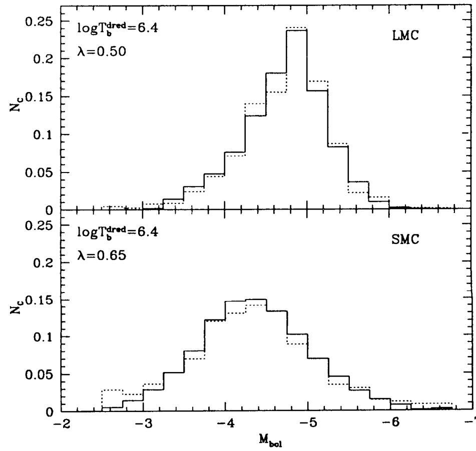

Figure 1. Observed LFs of carbon stars (dotted lines) in both Clouds, and the theoretical best fits (solid lines). The data are from Costa & Frogel (1996) for the LMC, and from Rebeirot et al. (1993; see also Groenewegen 1997) for the SMC.

Our best fitting model for the LMC is obtained with $\log T_{\rm b}^{\rm dred} = 6.4$ and $\lambda = 0.50$, and is shown in Fig. 1. It turns out that the parameter $T_{\rm b}^{\rm dred}$ essentially determines the faint end of the CSLF, that is the lowest luminosity level at which C-stars are expected to form. The efficiency λ essentially controls the peak location of the CSLF. We checked the sensitivity of the results to the assumed history of star formation (SFR). The faint wing and peak location are not affected by possible variations in the SFR occurring at ages older than $\sim 6\times10^8$ yr. On the contrary, it follows that the high luminosity tail could reflect the details of the recent (from 0.6 to 0.1 Gyr ago) history of star formation.

Interestingly, an excellent fit to the CSLF of the SMC is obtained from the $Z = 0.004$ models, with similar parameters, $\log T_{\rm b}^{\rm dred} = 6.4$ and $\lambda = 0.65$, and a constant SFR (Fig. 1). This result is in agreement with other theoretical indications that the third dredge-up is more efficient at lower metallicities.

References

Costa, E., & Frogel, J.A. 1996, AJ, 112, 2607

Groenewegen, M.A.T., & de Jong, T. 1993, A&A, 267, 410

Groenewegen, M.A.T. 1997, presented in: ISO's view on Stellar Evolution, Noordwijkerhout, The Netherlands (astro-ph/9708011)

Marigo, P., Bressan, A., & Chiosi, C. 1996, A&A, 313, 545

Marigo, P., Bressan, A., & Chiosi, C. 1998, A&A, 331, 564

Marigo, P. 1998, A&A, 340, 463

Rebeirot, E., Azzopardi, M., & Westerlund, B.E. 1993, A&AS, 97, 603

Vassiliadis, E., & Wood, P.R. 1993, ApJ, 413, 641

Wagenhuber, J., & Groenewegen, M. 1998, A&A, 340, 183

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