How to Make Carbon Stars: A New Approach to Model Boundaries of Convective Regions

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Observationally, most of the carbon and *s*-process enriched AGB stars are found at rather low luminosities indicating that they are *low-mass* stars ($1...3M_\odot$). Theoretically, we then meet two problems: (*i*) The 3^{rd} dredge-up, i.e. the mixing of interior carbon to the surface, is not found self-consistently for low initial masses, and (*ii*) temperatures are too low to activate the $^{22}Ne(\alpha,n)^{25}Mg$ reaction. Instead, the *s*-process is most likely driven by the $^{13}C(\alpha,n)^{16}O$ neutron source, raising the question how to mix protons into carbon-rich layers in order to produce sufficient amounts of ^{13}C.

We present stellar evolution calculations for Pop. I models which incorporate recent results of hydrodynamical simulations for stellar convection. The hydrodynamical models of Freytag, Ludwig & Steffen (1996, *A&A*, 313, 497) show that convective motions extend well beyond the Schwarzschild boundary of convective instability. The velocity field of the convective elements continues beyond that boundary and declines exponentially. Its scale height H_v is proportional to the pressure scale height, $H_v = f \cdot H_P$, with f depending on the stellar parameters considered. We treated convective mixing by solving a diffusion equation with diffusion coefficients given either by the mixing length theory for the "classical" convective regions or by the hydrodynamical simulations for the overshoot layers.

With this mixing treatment we found the 3^{rd} dredge-up not only for massive models (e.g. $7\,M_\odot$) but also for a low-mass model of $3\,M_\odot$ after 10 thermal pulses. The diffusive tail of the hydrogen profile leads to the formation of a ^{13}C pocket. Our calculations show that this pocket is burnt under radiative conditions before the onset of the next flash, confirming the findings of Straniero et al. (1995, *ApJ*, 440, L87).