Application of a Theory and Simulation-based Convective Boundary Mixing Model for AGB Star Evolution and Nucleosynthesis

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The s-process nucleosynthesis in Asymptotic giant branch (AGB) stars depends on the modeling of convective boundaries. We present models and s-process simulations that adopt a treatment of convective boundaries based on the results of hydrodynamic simulations and on the theory of mixing due to gravity waves in the vicinity of convective boundaries. Hydrodynamics simulations suggest the presence of convective boundary mixing (CBM) at the bottom of the thermal pulse-driven convective zone. Similarly, convection-induced mixing processes are proposed for the mixing below the convective envelope during third dredge-up (TDU), where the ${}^{13}{\rm{C}}$pocket for the s process in AGB stars forms. In this work, we apply a CBM model motivated by simulations and theory to models with initial mass M = 2 and $M=3\,{M}_{\odot }$, and with initial metal content Z = 0.01 and Z = 0.02. As reported previously, the He-intershell abundances of ${}^{12}{\rm{C}}$and ${}^{16}{\rm{O}}$are increased by CBM at the bottom of the pulse-driven convection zone. This mixing is affecting the ${}^{22}\mathrm{Ne}$(α, n)${}^{25}\mathrm{Mg}$activation and the s-process efficiency in the ${}^{13}{\rm{C}}$-pocket. In our model, CBM at the bottom of the convective envelope during the TDU represents gravity wave mixing. Furthermore, we take into account the fact that hydrodynamic simulations indicate a declining mixing efficiency that is already about a pressure scale height from the convective boundaries, compared to mixing-length theory. We obtain the formation of the ${}^{13}{\rm{C}}$-pocket with a mass of $\approx {10}^{-4}\,\,{M}_{\odot }$. The final s-process abundances are characterized by $0.36\lt [{\rm{s}}/\mathrm{Fe}]\lt 0.78$and the heavy-to-light s-process ratio is $-0.23\lt [\mathrm{hs}/\mathrm{ls}]\lt 0.45$. Finally, we compare our results with stellar observations, presolar grain measurements and previous work.
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