Oxygen isotopic ratios in first dredge-up red giant stars and nuclear reaction rate uncertainties revisited [J. A. Stoesz and F. Herwig]Jeffrey A. Stoesz[1,2] and Falk Herwig[1]E-mail: fherwig@uvastro.phys.uvic.ca

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Submitted Sept 2002

firstpage–lastpage 2002

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abstract We describe a general yet simple method to analyse the propagation of nuclear reaction rate uncertainties in a stellar nucleosynthesis and mixing context. The method combines post-processing nucleosynthesis and mixing calculations with a Monte Carlo scheme. With this approach we reanalyze the dependence of theoretical oxygen isotopic ratio predictions in first dredge-up red giant branch stars in a systematic way. Such predictions are important to the interpretation of pre-solar Al_2O_3 grains from meteorites. The reaction rates with uncertainties were taken from the NACRE compilation nacre. We include seven reaction rates in our systematic analysis of stellar models with initial masses from 1 to 3 M. We find that the uncertainty of the reaction rate for reaction $^{18}\mathrm{O}(\mathrm{p},\alpha)^{15}\mathrm{N}$ typically causes an error in the theoretical $^{16}\mathrm{O}/^{18}\mathrm{O}$ ratio of $\simeq +20/-5$ per cent. The error of the $^{16}\mathrm{O}/^{17}\mathrm{O}$ prediction is 10–40 per cent depending on the stellar mass, and is persistently dominated by the comparatively small uncertainty of the $^{16}\mathrm{O}(\mathrm{p},\gamma)^{17}\mathrm{F}$ reaction. With the new estimates on reaction rate uncertainties by the NACRE compilation, the p-capture reactions $^{17}\mathrm{O}(\mathrm{p},\alpha)^{14}\mathrm{N}$ and $^{17}\mathrm{O}(\mathrm{p},\gamma)^{18}\mathrm{F}$ have virtually no impact on theoretical predictions for stellar mass ≤ 1.5 M. However, the uncertainty in $^{17}\mathrm{O}(\mathrm{p},\alpha)^{14}\mathrm{N}$ has an effect comparable to or greater than that of $^{16}\mathrm{O}(\mathrm{p},\gamma)^{17}\mathrm{F}$ for masses > 1.5 M, where core mixing and subsequent envelope mixing interact. In these cases where core mixing complicates post-dredge-up surface abundances, uncertainty in other reactions have a secondary but noticeable effect on surface abundances.