Abstract #174

Impact of Overshoot on Proton Ingestion Events in AGB Stars

Bryce Remple, Tiara Battich, and Achim Weiss

Scan for full article

Introduction

- The *i*-process or intermediate neutron-capture process may occur in low-mass, low-metallicity AGB stars during so-called proton ingestion events (PIEs), in which protons are ingested into a hot He-burning convective region (see Fig. 3).
- (Some) mass lost from the star is accreted by a companion, polluting its surface, and turning it into a carbon-enhanced metal-poor star with *i*-process enhancements (CEMP-r/s star) which we observe today.
- This study seeks to show how convective overshoot influences the structure, neutron density, and light element nucleosynthesis of these AGB stars.

Methods

- The models are computed with the GARSTEC stellar evolution code. All models are of a $M_{initial}=1.2M_{\odot}$ star with a metallicity of $Z=5\times10^{-5}$ ([Fe/H] = −2.56).
- Differing overshoot values were applied independently to the base of the convective envelope (fCE) and to the top and bottom of the pulse driven convection zone (fPDCZ) during the AGB phase.
- The neutron densities are estimates based on the neutron sink approach implemented into the 34 isotope nuclear network.
- Results are compared to observed CEMP-r/s stars.

Results

- With increasing overshoot, the neutron densities and neutron exposures decrease (see Fig. 1).
- Comparison to observations of abundance ratios in CEMP-r/s stars shows a worsening agreement with increasing overshoot. (see Fig. 2).
- Li is produced in large quantities in all models (see Fig. 4).

Overshoot impacts both the neutron density and light element nucleosynthesis of PIEs.

Comparison to observations strongly favors smaller overshoot values.

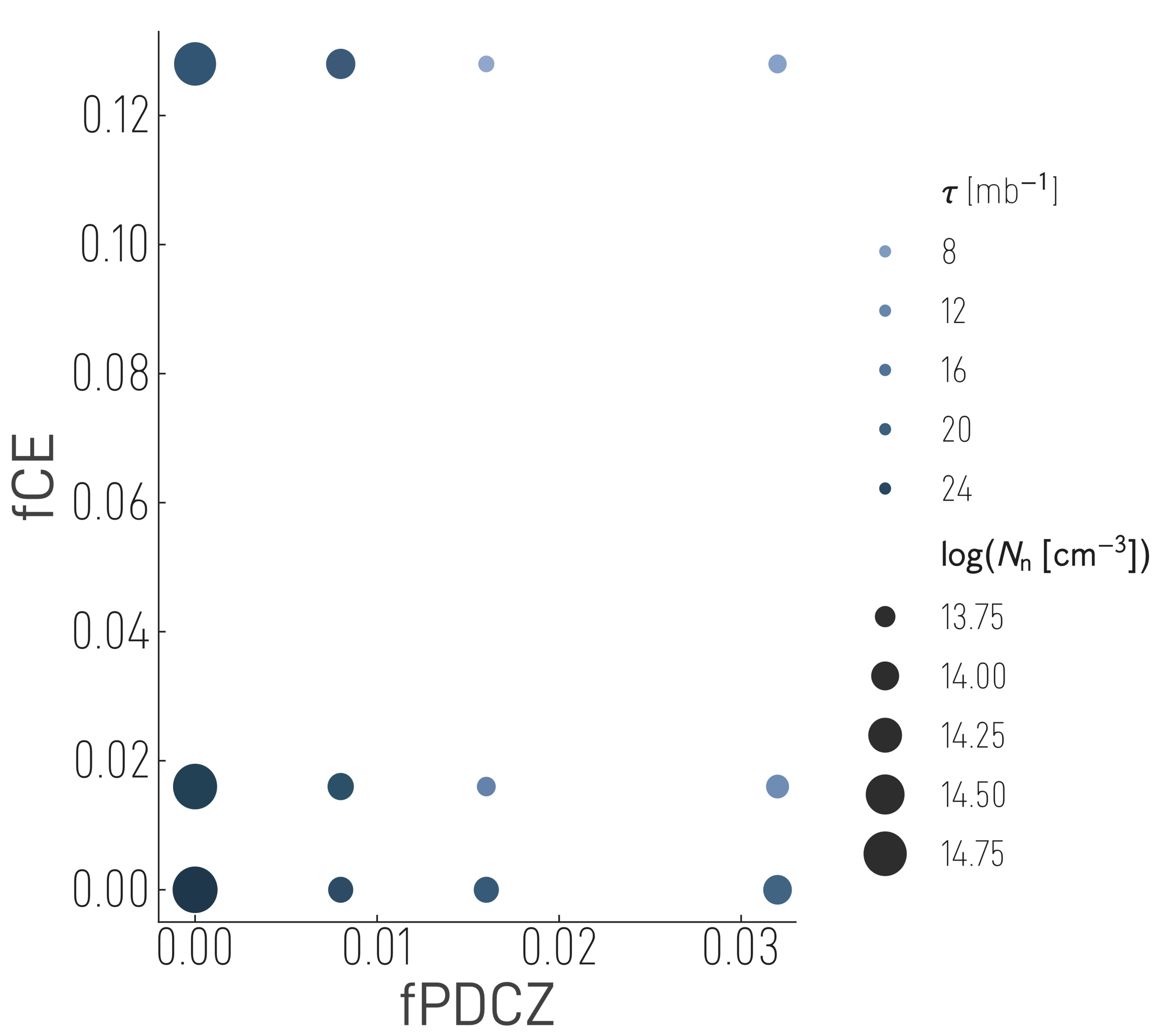

Figure 1. The impact of the convective overshoot parameters, fPDCZ and fCE, on the maximum neutron density (marker size) and neutron exposure (marker hue).

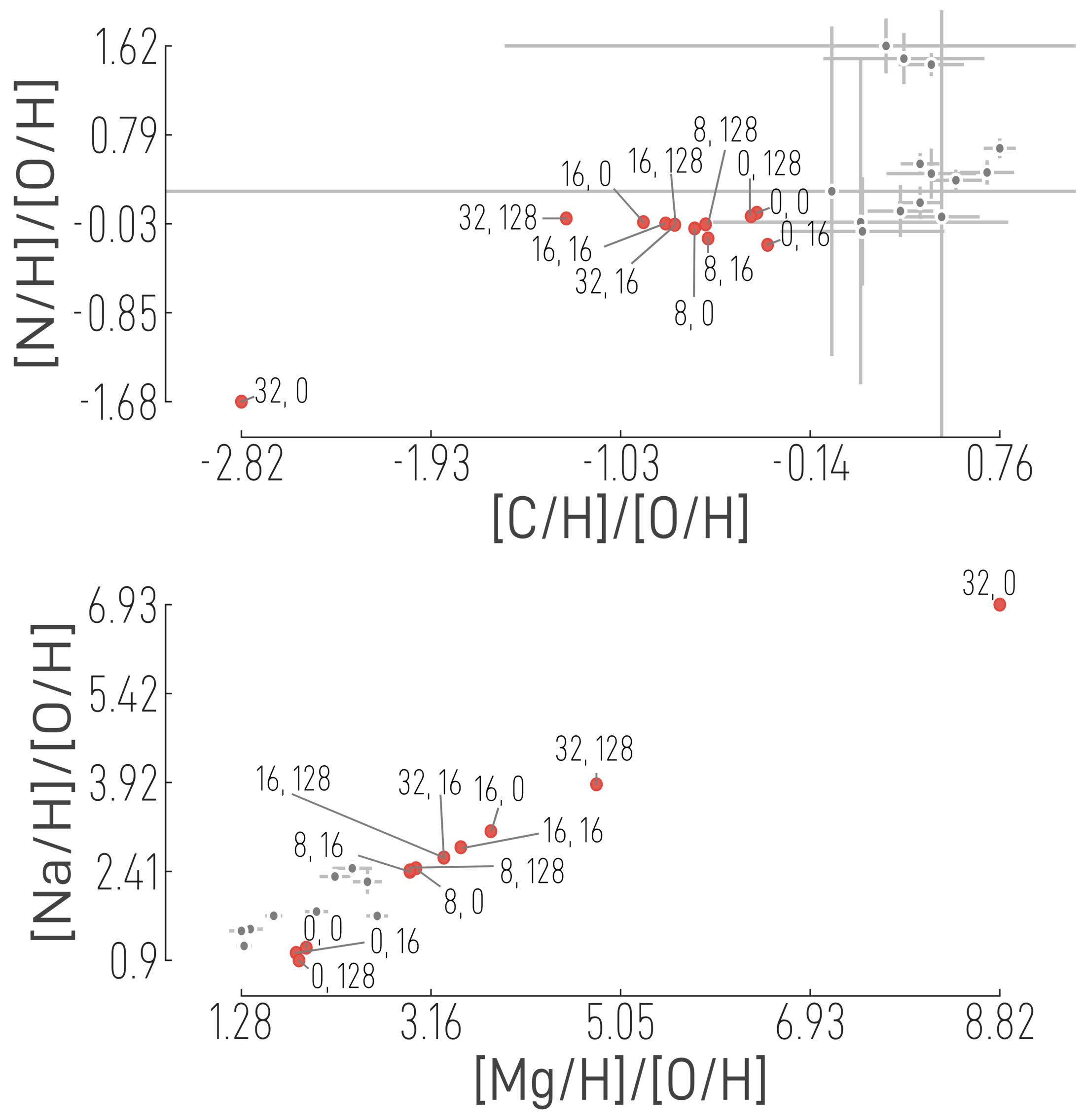

Figure 2. Final surface abundance ratios of models (red dots) and observed CEMP-r/s stars with observational errors (gray dots). The models are labelled as fPDCZ, fCE with the values multiplied by 1,000.

Observational Data: Karinkuzhi et al. (2021), Aoki et al. (2007), Ivans et al. (2005), Roederer et al. (2014), Aoki et al. (2002), Aoki et al. (2006), Hansen et al. (2015), Jonsell et al. (2006), Zhang et al. (2011), Cohen et al. (2003), Cohen et al. (2013), Placco et al. (2013).

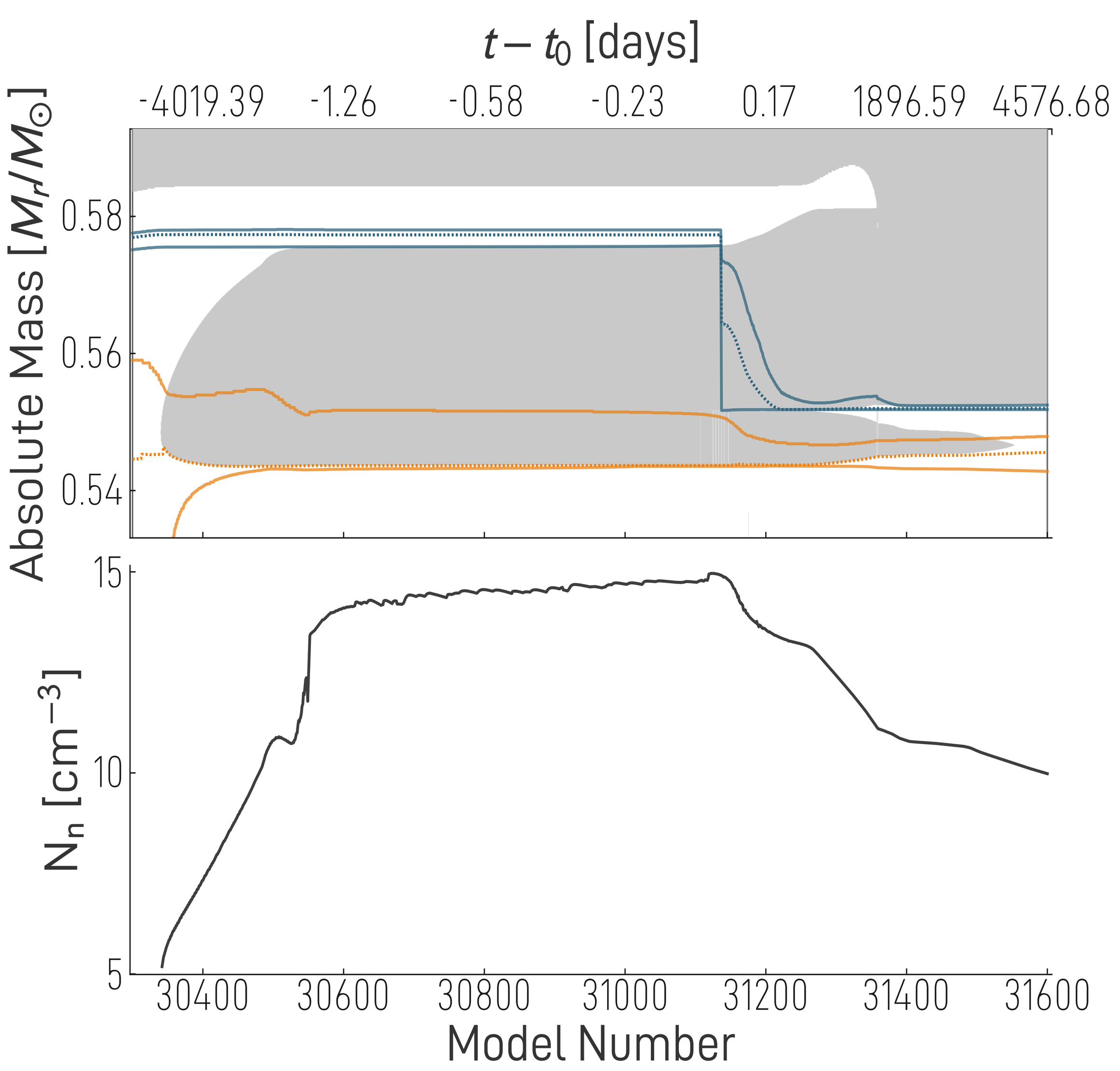

Figure 3. Kippenhahn diagram (top) and maximum neutron density per time step (bottom) of a PIE for the model without overshoot. Blue solid lines denote the borders of the H shell, and the dotted blue line is the point of maximum energy release. The same is true of the orange lines but for the He shell. Gray regions denote convection zones. Time on the upper x-axis is given relative to the point where the neutron density reaches its maximum.

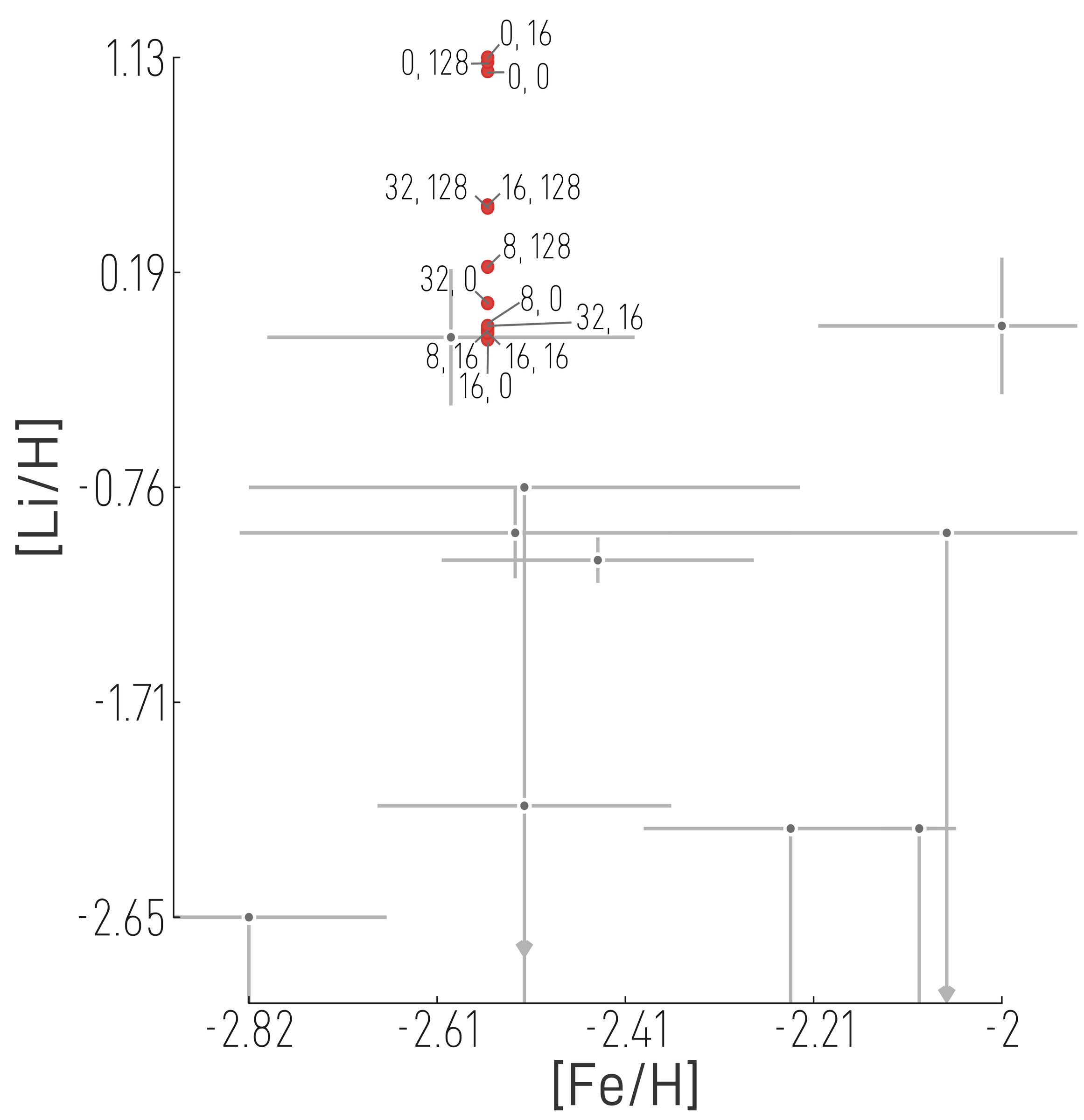

Figure 4. Final surface abundance of Li in the models (red dots) and observed CEMP-r/s stars with observational errors (gray dots). The models are labelled as fPDCZ, fCE with the values multiplied by 1,000.

Observational Data: Masseron et al. (2012), Aoki et al. (2002), Sivarani et al. (2004), Aoki et al. (2008), Susmitha et al. (2021).

Future Work

- The models will be post-processed to see how overshoot affects the abundances of the heavy elements.
- The analysis will be extended different masses and metallicities.

Contact

Bryce Remple
brempl@mpa-garching.mpg.de

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN ORIGINS Excellence Cluster MAX-PLANCK-INSTITUT FÜR ASTROPHYSIK