Determination of Nucleosynthesis Uncertainties with the PizBuin Monte Carlo Code: Production of p Nuclides in Thermonuclear Supernovae

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The Monte Carlo (MC) framework PizBuin was developed to study nuclear uncertainties by postprocessing large reaction networks with trajectories obtained from a variety of nucleosynthesis sites. We perform large-scale MC variations using temperature-dependent rate uncertainties combining experimental and theoretical uncertainties. From detailed statistical analyses, realistic uncertainties on the final abundances are derived as probability density distributions. Furthermore, based on rate and abundance correlations an automated procedure to identify the most important reactions in complex flow patterns from superposition of many zones or tracers is used. This method is superior to visual inspection of flows and manual variation of limited rate sets.
Here, we first present the general approach which already has been used to study uncertainties in the γ process [1] and the weak s-process in massive stars [2]. Then we focus on new results concerning the application of PizBuin to the production of p nuclei in white dwarfs exploding as thermonuclear (type Ia) supernovae [6]. (Further new results for the main s process [3, 4] and the νp process [5] are presented elsewhere at this conference.) The computationally very demanding study combined more than 4600 tracers to determine overall uncertainties originating from uncertainties in the nuclear input and the associated key reactions. Compared to the results we previously obtained for the γ process in massive stars [1] it is found that the uncertainties are smaller and fewer key reactions can be identified. This is due to the larger range of conditions encountered in thermonuclear supernovae, causing a multitude of possible flow patterns, avoiding bottlenecks and diminishing the impact of uncertainties in specific, isolated reaction rates. Despite of the fact that we used a particular 2D model of a white dwarf explosion, separately studying high density and low density regions allows to draw more general conclusions, also applicable to other explosion models.
The relevance of these findings in the broader context of Galactic Chemical Evolution is briefly addressed [7, 8].

References

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