The Joint Institute for Nuclear Astrophysics

Critical Nuclear Reactions in the νp-Process

Researchers: Frohlich (NCSU), Rauscher (Basel), Tang (Notre Dame), Truran (U Chicago; ANL)
Contact: cfrohli@ncsu.edu

JINA

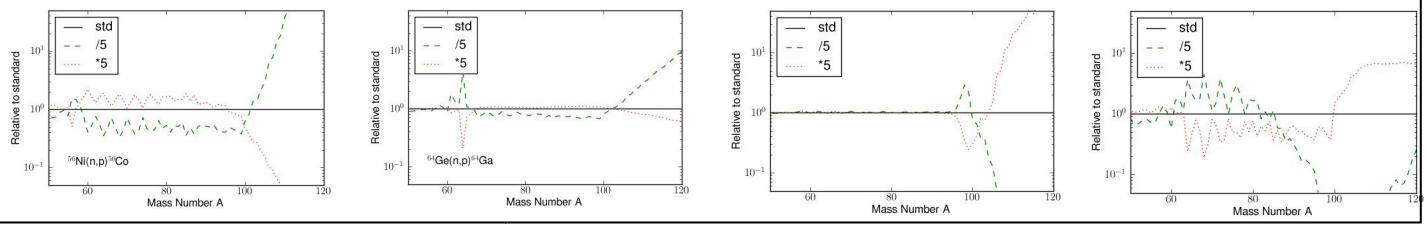
The νp-process is thought to occur in the innermost proton-rich layers ejected in core-collapse supernovae. The importance of the νp-process lies in the fact that it may contribute to the abundances of elements above Nickel and possible the light p-nuclei. The reaction path of the νp-process lays in a region where nuclear masses are partly unknown and all involved reaction rates are based on theoretical predictions. Detailed studies of the νp-process nucleosynthesis and its uncertainty due to the nuclear physics are presented, with a focus on the reaction path at and above 56Ni. The νp-process path is found to be mainly determined by nuclear structure and thus is trajectory independent. Critical nuclear physics inputs are identified and the impact of uncertainties on the resulting nucleosynthesis is discussed.

Supernova outflow model: Neutrino wind trajectories from the hydrodynamical simulation of a 15 Msun star, following the onset of the explosion and the subsequent neutrino-driven wind.

Nucleosynthesis calculations: Post-processing approach using a full nuclear reaction network of 1901 nuclei from free nucleons to Dysprosium.

Reaction rates: REACLIB. Complimented with Hauser-Feshbach rates using the most recent mass measurements for nuclei with Z>28. Weak interaction rates and neutrino interactions are also included.

Results: Abundance ratios for variations of (n,p) reactions on nuclei with Z≥28



Results: Left - Abundance distribution from (p,γ)-(γ,p) equilibrium in each isotonic chain for typical νp-process conditions (magenta – high abundance; turquoise – low abundance). Arrows indicate the dominating net flux per nucleus. Circles denote nuclei where uncertainties in the Q-values (masses) impact the dominating reaction flow. Diamonds mark nuclei where the path direction is uncertain due to uncertainties in the reactions. Right – Same but with destruction lifetimes against the dominating reaction (blue – long lifetime; green – short lifetime).