Numerical simulations of dynamic i-process nucleosynthesis in stars constrained by nuclear physics experiments and astrophysical observations

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Carbon-enhanced metal-poor (CEMP) stars carry the signature of neutron-capture processes in the early universe. It has been thought so far that many of the CEMP stars show slow-neutron capture products. However, new simulations that take into account the the time-dependent hydrodynamic nature of convective-reactive He-burning convection with dynamic H ingestion and nuclear-hydro feedback show that the intermediate n-capture processes with time-dependent termination may be the origin of heavy-element abundances observed in most CEMP stars. The i-process path proceeds through unstable species about two to six masses away from stability. Understanding the astrophysical, hydrodynamic processes of the intermediate n-capture process depends critically on the highly uncertain n-capture cross sections of unstable species. The astrophysical context of the i process and its astronomical manifestation in CEMP stars provides a rich testbed for nuclear data validation. Based on our Monte Carlo simulations, in which all rates are varied within a range estimated from Hauser-Feshbach models and parameter variations and comparison with observed CEMP star abundances we predicted corrections to Hauser-Feshbach n-capture rates for ^{139}Ba, ^{88}Kr, and ^{75}Ga, which have already been experimentally verified for the first two isotopes. A scheduled experiment on constraining the neutron-capture rate for ^{75}Ga will be a key test for the hypothesis that its reduced value is responsible for the high As to Ge i-process abundance ratio in the star HD94028.