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The origin of CEMP-i stars - Results from a comprehensive multi-method simulations approach

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Most C-enhanced metal poor stars show substantial enhancements of heavy n-capture elements, mostly of second-peak elements such as Ba, La and Eu. We report on a comprehensive simulation program involving 3D hydrodynamic simulations, 1D stellar evolution and nucleosynthesis simulations, galactic chemical evolution simulations as well as novel approaches to neutron-capture nucleosynthesis simulations. We start by introducing a classification of CEMP stars based on equilibrium neutron-density elemental ratio predictions that depend only on nuclear physics data, and are independent of any specific astrophysical site. Based on this approach we interpret the JINAbase databased of CEMP stars, and find that many stars labeled as CEMP-s cannot be reproduced by s-process neutron density models, but instead by the intermediate neutron density in the range $13 < \log N_n < 16$, demonstrating the importance of the i process for understanding the heavy-element patterns in CEMP stars. We will then present our current understanding of the i process as a prime example of a convective-reactive nuclear process that relies on the simultaneous coupling of hydrodynamic convective boundary mixing, entrainment and advection processes with detailed, heavy-element neutron-cature nucleosynthesis. I will present a brief survey of candidate stellar sites of the i proces, such as low-Z AGB and super-AGB stars, massive stars and post-AGB stars. The key ingredient of the convective-reactive i process is the H-ingestion into convective He-burning layers. However, the volatile nature of this process, as demonstrated through our 3D hydrodynamic simulations, poses also a great challenge to the viability of these sites. The new i-process site that we discovered recently in rapidly accreting white dwarfs (RAWDs) is less volatile, and therefore promising in that regard. Our CEMP-i star abundance predictions for RAWDs are based on our new coupled 3D1D hydro-nucleosynthesis approach and reproduce the abundances of CEMP-i stars all the way from C to Pb remarkably well. We have also demonstrated through galactic chemical evolution simulatiopns, that i process in RAWDs may contribute substantially to some first-peak elements in the solar system. The important nuclear physics data impact on interpretations of CEMP stars will be demonstrated.

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