Waiting Points in Nova and X-ray burst Nucleosynthesis

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Novae and X-ray bursts are driven by sequences of thermonuclear reactions on proton-rich unstable nuclei - including the Hot CNO cycle, the rp-process, and the \(\alpha p\) process. These reaction sequences, often visualized as a “flow” up the chart of nuclides, directly determine the observable luminosity as a function of time and the abundances synthesized in these explosive events.

One way to more thoroughly understand the nuclear reaction sequences in these explosions is to better determine the reactions involving, and structure of, waiting points. Waiting points are nuclei in the reaction path which interrupt the nuclear flow towards heavier nuclei. They are so named because they typically have little flow through the proton capture reaction and a long \(\beta^+\) lifetime, and the flow “waits” for the long decay before heavier nuclei are synthesized. There is, unfortunately, no systematic, quantitative definition of rp-process waiting points and their identification is not straightforward. A variety of criteria have been sporadically applied in the past to determine waiting points. These criteria have included \((p,\gamma)\) reaction \(Q\)-value, \(\beta^+\) lifetime, change in abundance, and others.

We have constructed a quantitative set of criteria for rp-process waiting points to aid in their identification. We use these criteria to search for waiting points in post-processing simulations of novae and X-ray bursts. These criteria have been incorporated into the Computational Infrastructure for Nuclear Astrophysics, a suite of nuclear astrophysics codes available online at nucastrodata.org. With this new software tool, users can now specify a simulation, a time window, and values of parameters that define waiting points, and let the system determine which nuclei satisfy these criteria. The first utilization of this quick and easy determination of waiting points on a number of novae and X-ray burst simulations will be presented.

\textsuperscript{*} ORNL is managed by UT-Battelle, LLC for the U.S. Department of Energy under contract DE-AC05-00OR22725.