NEW TECHNIQUES FOR INTEGRATING NUCLEAR REACTION NETWORKS

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The development of high resolution stellar models in multiple dimensions has moved us one step closer to answering fundamental questions of how stars burn their fuel. These models rely on solving a computationally expensive set of conservation, transportation, and energy production equations, the latter of which is determined by a complex network of nuclear reactions. The size of this network is constrained by the nature of the stellar environment in question and whether detailed nucleosynthesis yields are required. Alternatively, the nucleosynthesis yields can be computed by decoupling the calculation into a post-processing nucleosynthesis part, which relies on the output of a simplified hydrodynamics-focused calculation. Here, we investigate improving post-processing calculation performance by using more advanced integration methods than those typically adopted in nuclear astrophysics research. These are the Bader-Deuflehard multi-step method and the Gear backward differentiation method, which are compared with the traditional Wagoner two-step method. Integration method performance is quantified for a range of stellar environment models including Novae, X-ray bursts, hydrostatic core helium burning, and explosive hydrogen-helium burning in white dwarf merger events. We show that by using these methods, nucleosynthesis integration accuracy can be greatly improved and computation time can be significantly reduced by up to two orders of magnitude. Applicability of the integration methods to full hydrodynamical models will also be outlined.