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Uncertainties in explosive nucleosynthesis in core-collapse supernovae from Monte Carlo variation of reaction rates

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Massive stars (>10M_{9737;}) undergo core-collapse supernova explosions at the end of evolution. These explosions release elements ranging from helium (produced during the stellar evolution) to iron peak synthesized in explosive nucleosynthesis. Although the explosion mechanism of core-collapse supernovae is not fully understood, 1D spherically symmetric explosion models have been constructed that relatively well reproduce the observed elemental abundances. Such models are ideal to systematically study the impact of nuclear reaction rates on the nucleosynthesis. Some of the nuclear reactions in explosive nucleosynthesis, can be accessed through accelerator experiments.

We have developed a nucleosynthesis code with Monte-Carlo framework that accounts for nuclear reaction uncertainties and applied it to processes beyond iron. Given its general applicability, our framework is naturally suited for studying supernova explosive nucleosynthesis. In this study, we investigate 1D explosion models using the “PUSH” method, which simulates explosions by mimicking the enhanced neutrino heating observed in multi-dimensional simulations. We focus on nucleosynthesis in progenitors with solar and sub-solar metallicity around M_{ZAMS}=16 M_{9737;}. Detailed post-process nucleosynthesis calculations with Monte Carlo analysis is employed to comprehensively explore the effects of uncertainties in relevant reaction rates. Additionally, we identify “key reaction rates”, based on statistical analysis of our Monte Carlo results.

Primary author: NISHIMURA, Nobuya (The University of Tokyo)

Co-authors: FRÖHLICH, Carla (North Carolina State University (NCSU)); RAUSCHER, Thomas (University of Basel)

Presenter: NISHIMURA, Nobuya (The University of Tokyo)

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