

R-process Nucleosynthesis in Core-collapse Supernova Explosions and Binary Neutron Star Mergers

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R-process nucleosynthesis in core-collapse supernova explosions (CCSNe) and binary neutron star mergers (NSMs), both of which are promising candidates for the r-process sites, are studied using new beta-decay half-lives for the waiting-point nuclei obtained by shell-model calculations.

We here investigate how the change of beta-decay half-lives affects the r-process nucleosynthesis. Beta decay rates for exotic nuclei with neutron magic number of $N=126$ are evaluated up to $Z=78$ by including the contributions from both the Gamow-Teller and first-forbidden transitions. The half-lives obtained prove to be short compared to a standard finite-range-droplet model (FRDM), in particular near ^{208}Pb region due to the effects of the first-forbidden transitions.

The element abundances for the r-process in neutrino-driven wind CCSNe, magnetohydrodynamic jet CCSNe and binary NSMs are obtained up to the third peak as well as beyond the peak region up to thorium and uranium. The position of the third peak is found to be shifted toward a higher mass region in both CCSNe and NSMs. We find that thorium and uranium elements are produced more with the shorter shell-model half-lives and their abundances come closer to the observed values in CCSNe. In case of binary NSMs, thorium and uranium are produced as much as consistent with the observed values independent of the half-lives. This suggests that NSMs are promising robust r-process sites for producing very heavy elements such as thorium and uranium.

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