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Large-scale shell model study of β^--decay properties of $\mathrm{N} = 126, 125$ nuclei along the r-process path

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The rapid neutron capture process (r-process) is the most important mechanism for the synthesis of about half of the elements heavier than iron. It occurs in an environment with relatively high temperatures and high neutron densities. The abundances of the elements created by the r-process strongly depend on several nuclear inputs like masses, neutron capture rates, β-decay rates, and β-delayed neutron emission probabilities at the waiting point nuclei. Among them, the β-decay process plays a crucial role in the r-process. In this work, we have investigated various nuclear β-decay properties of $N = 126, 125$ isotones with proton numbers $Z = 52 - 79$ within the framework of the nuclear shell model. This comprehensive analysis considered both Gamow-Teller (GT) and first-forbidden (FF) transitions to evaluate β-decay rates. We have found that including FF transitions in addition to GT transitions is essential, as they significantly impact the total β-decay half-lives near $Z = 82$. Additionally, we systematically analyzed the GT strength distributions as a function of proton number. We have observed that the GT strengths at low excitation energies are rather strong on the proton deficient side due to the increasing number of proton holes in the proton $0h_{11/2}$ orbit, which accelerates GT decay. This investigation aims to provide detailed information on β-decay properties around $A \approx 195$ to understand the distribution of the third r-process abundance peak.

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