Evaluation of the astrophysical rates of the ${}^{42}\text{Ti}(p,\gamma){}^{43}\text{V}$ and ${}^{43}\text{V}(p,\gamma){}^{44}\text{Cr}$ reactions

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In this study we estimated the astrophysical rates of the ${}^{42}\text{Ti}(p,\gamma){}^{43}\text{V}$ and ${}^{43}\text{V}(p,\gamma){}^{44}\text{Cr}$ reactions and their variations due to mass uncertainties of the ${}^{43}\text{V}$ and ${}^{44}\text{Cr}$ exotic nuclei in the rp-process. The associated photodisintegration related to the $(p,\gamma) - (\gamma,p)$ equilibrium is also considered. The results show that the photodisintegration-rate variation of the ${}^{42}\text{Ti}(p,\gamma){}^{43}\text{V}$ and ${}^{43}\text{V}(p,\gamma){}^{44}\text{Cr}$ reactions are decreased at higher temperatures. The proton-capture rate variation between those reactions at $T_9 = 0.5$ is about 35% while it is approximately 60% at $T_9 = 2.0$. We found that the rate variation less than 20% if the precise mass of 10 keV can be achieved. To reduce the variation of the astrophysical rates, the precise mass measurements using MR-TOF technique at future facility RAON is suggested. Therefore, we also analyzed the resolving power, mass precision, counting rate, timing spread, and the half-life of the exotic isotopes for the MR-TOF technique. It is found that to achieve a mass accuracy of 0.1 ppm at the resolving power 10^5 , a counting number of 10^4 is required for the isotopes. In addition, the half-life of the exotic nuclei must be longer than 10 ms for the reflections in the measurements using MR-TOF systems.

Keywords: mass uncertainty, reaction rates, rp-process, MR-TOF technique, exotic isotopes, timing spread, resolving power.

Field of your work

Astrophysics

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