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In-beam Measurement of 74Ge(p,γ)75As Reaction to Probe the Production Mechanism of Light p-process Nuclei

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- Introduction

The origin of heavy elements in the universe is an important frontier in the field of nuclear astrophysics. The p-process is mainly responsible for synthesizing the heavy elements on the proton-rich side[1]. 74Se is the lightest nucleus in the p-process, but its abundance predicted by the stellar model is three times higher than astronomical observations due to the lack of cross section data or their precision. 74Ge(p, γ)75As is the most critical nuclear reaction affecting 74Se abundance. For a typical stellar environment, the Gamow window of the 74Ge(p, γ)75As reaction is 1.2-3.8MeV, while so far, the previous experiments have been performed down to 1.6MeV[2,3].
We measured the cross section for Ep=1.4-2.8MeV using the 2×1.7 MV high-current tandem accelerator of the China Institute of Atomic Energy (CIAE).

- Method

Four high-purity germanium (HPGe) detectors were used to measure the prompt γ decays and its angular distribution cursed by proton capture reactions. Three detectors have a relative detection efficiency of 35%, and the fourth detector has a relative efficiency of 40%. The detectors were set as close as possible around the target. As shown in Figure 3, the distance was 8-9cm and the angle was 12°, 58°, 107.5° and 150° to the beam axis. The detector efficiency was calibrated with 152Eu source and 27Al(p, γ) reaction for Ep=992keV and Ep=760keV[4].
The target was made by evaporating 99.8% enriched 74Ge onto a thick tantalum backing using the evaporator at the CIAE. A target thickness of 283.3(15.0)μg/cm2 was verified through Rutherford Backscattering Spectrometry (RBS) performed at the tandem accelerator of Beijing Normal University. The 74Ge target was set at the end of a target pipe and was air-cooled during the experiment[5].
The proton energy was 1.4MeV-2.8MeV while the average energy loss in 74Ge target was 26.6keV-17.8keV, respectively. The beam intensity was set around 5μA, and was measured by a beam integrator. The target pipe was insulted from the rest of the accelerator, and it is 40cm long so that the loss of the secondary electrons was negligible.

- Result

In this experiment, 35 transitions to the g.s. were observed. For branching ratio differs from each proton energy, all transitions to the g.s. were used in the calculation of the total cross section. The angular distribution of all transition to g.s. was analyzed and fit by a sum of Legendre polynomials. Then the total cross section was given by the sum of each transition to g.s.. More then 980 peaks were analyzed in the spectrum for seven energise.
Because of the large distance between detector and target and the low count rate, summing effects of the γ rays are negligible.

- Conclusion

The total cross sections of the 74Ge(p, γ)75As reaction were measured between 1.4 and 2.8 MeV using the in-beam γ spectroscopy measurement with HPGe detectors. The result matched with S.J. Quinn et al. and A. Suaerwein et al. very well, and provide cross sections data down to Ep=1.4MeV. The result would contribute to the stellar model and provide a better abundance prediction of the lightest p nucleus 74Se.

- Reference

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Abstract Type

Talk

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