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Selection of activation foil for error reduction of benchmark experiment on large angle elastic scattering reaction cross section of Li by 14 MeV neutron/リチウムの 14MeV 中性子大角度散乱断面積ベンチマーク実験における誤差低減のための放射化箔の選定

Thursday, 14 November 2024 16:00 (2 hours)

In high-energy and high-intensity neutron environments, such as the fusion reactor blanket, large angle scattering reaction cross sections significantly affect neutron transport calculation results. C. Konno has identified discrepancies between experimental and calculated values in the blanket benchmark experiments in Japan Atomic Energy Agency (JAEA) [1]. Therefore, benchmarking studies for large angle scattering cross sections are indispensable. The authors'group developed a benchmark experimental system utilizing the foil activation method to validate these cross sections [2]. Four experiments for a certain sample were conducted using two shadow bars composed of conical irons with and without the sample to extract large angle scattering neutrons.

In the previous study, we performed a benchmark experiment for lithium using hafnium as the activation foil. However, due to lithium's low mass, detecting large angle scattering neutrons was challenging, leading to considerable experimental errors caused by neutrons scattered from walls and other surrounding materials. In that study, to investigate whether large angle scattered neutrons from lithium could be detected, the counts obtained with the Ge detector and the associated statistical errors were calculated when various elements were used as the activation foil, concluding that hafnium was the best activation foil. However, the statistical error estimation did not account for background contributions, a significant factor in the experiment. Furthermore, the cooling and measurement times required further optimization.

In this study, we recalculated the statistical error by considering background effects and recalibrating the cooling time, and obtained statistical errors at various measurement times. Six isotopes were selected for measurement based on factors such as isotope abundance, activation cross section, threshold value, and half-life. The reaction rate for each activation reaction was calculated using MCNP5, the Ge detector counts were determined, and the statistical error was recalculated. Our results indicated that using the ^{24}Mg(n, p)^{24}Na reaction with magnesium as the activation foil the lowest statistical error was obtained, i.e., approximately one-third of that obtained when using hafnium. In addition, it was found that modifying the thickness of the activation foil further reduced the statistical error.

In the future we will develop an experimental system that could further minimize statistical errors by optimizing the materials and configurations of surrounding components of the experimental assembly, and carry out benchmark experiments with the assembly for large angle scattering cross section for lithium using magnesium as the activation foil to obtain highly accurate experimental results.

References

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