STUDY OF THE RATES AND CROSS SECTIONS OF PHOTONUCLEAR REACTIONS IN $^{\mathrm{nat}}\mathrm{Mg}$ NUCLEI AT ENERGIES UP TO 20 MeV

Systematic studies of photonuclear reactions (primarily photoneutron ones) started in the middle of the twentieth century. The interaction between the photon and the nucleus has only an electromagnetic effect and can be well explained through photonuclear reactions. These reactions have clear advantages over other nuclear reactions in description and interpretation. At the same time, experimental studies of photon–nucleus interactions have many specific difficulties, and the most important one is that intense monoenergetic photons can hardly be foundin nature.

In our work, we studied the element magnesium. Natural magnesium consists of three stable isotopes $-^{24}\mathrm{Mg}$ (isotopic abundance is 78.96 %), $^{25}\mathrm{Mg}$ (isotopic abundance is 10.01 %) and $^{26}\mathrm{Mg}$ (isotopic abundance is 11.03 %). Magnesium nuclei have Z = 12 protons. The number of neutrons in them is N = 12, 13 and 14, respectively. The ground states of magnesium isotopes are $^{24}\mathrm{Mg}$ ($J = 0^+$), $^{25}\mathrm{Mg}$ ($J = 5/2^+$) and $^{26}\mathrm{Mg}$ ($J = 0^+$).

The experiments were carried out at the LINAC-200 Linear Electron Accelerator [1]. A tungsten converter 4.5 x 4.5 x 0.5 cm was used to generate bremsstrahlung gamma rays. In this work, we used the accelerated electrons with an energy of 20 MeV. The sample are of natural magnesium with sizes of 1.0 x 1.0 x 0.18 cm. For irradiation, it was placed behind the tungsten converter.

The irradiated magnesium sample were transferred to the measurement room, and their gamma spectra were measured using the HPGe detector (CANBERRA, GR1819). The gamma spectra obtained were processed using the DEIMOS32 program [2] , which fits the count area of the full-energy peaks with a Gaussian function.

Currently, the Geant4 program [3] is the most widely used Monte Carlo radiative transport code for the study of photonuclear reactions. We compare the experimental results obtained in this study with the Geant4 prediction based on the Monte Carlo simulation (MC) for the flow of photons, electrons and neutrons in the samples. For photonuclear interactions in Geant4, the G4PhotoNuclearProcess Class [4] was used. Cross sections σ(E) of the photonuclear reactions studied were calculated with the TALYS-1.96 program [5].

From the analysis of the measured gamma spectra, we identified the photoproton reaction with the release of one proton from nuclei, inelastic scattering of photons in nuclei. The experimental yield 1.04(12)E-29 $atom^{-1}$ • $electron^{-1}$ of photoproton reaction $^{25}\mathrm{Mg}(\gamma, p)^{24}\mathrm{Na}$ in the $^{25}\mathrm{Mg}$ nuclei per one 20-MeV electron incident onto a tungsten converter and corresponding results of MC calculations 0.76E-29 $atom^{-1}$ • $electron^{-1}$. The reaction yields during the experiment were compared with the Monte Carlo simulations, which resulted in the ratio of the calculated and experimental data in the range of 0.73.

For representing the experimental photonuclear reaction data, the experimental cross section per equivalent photon $_q$ and the flux weighted average cross sections $< >$ were calculated. In addition, a quasi-monochromatization method [6] was used to determine the cross section of the reaction. The cross sections from the TALYS software 6.15 mb for $^{25}\mathrm{Mg}(\gamma, p)^{24}\mathrm{Na}$ reaction and those determined from the experimental data by the quasi-monochromatization method 7.79 ± 1.24 mb, for photoproton reaction.

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Section

Nuclear physics (Section 1)

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