Double differential cross section of the (γ,xn) reaction on medium-heavy nuclei for 16.6 MeV polarized photons

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Double differential cross sections (DDXs) of the (γ,xn) reaction on medium-heavy nuclei for 16.6 MeV polarized photons were obtained at NewSUBARU, BL01, Hyogo, Japan. The angular dependence of photo-neutrons will be discussed in this report.

Keywords: photo-neutrons, angular distribution, 16.6 MeV polarized photons.

1. **Introduction:** Energy and angular distribution of neutron emitted from the photonuclear reaction are important for the electron accelerator design. In the previous presentation [1,2], we identified the evaporation and non-evaporation components of neutrons emitted from (γ,xn) reaction with linearly polarized photons for medium-heavy targets. Kirihara et al. successfully showed the angular dependence of non-evaporation components was obtained by $a+b\cdot\cos(2\Theta)$, with Θ is the angle between the polarization direction of photon and detector direction. In this presentation, we will discuss about the angular distribution of these two components.

2. **Experiment**: We used the experimental setup reported in [1,2]. The 16.6 MeV polarized photons were produced using Laser Compton Scattering (LCS). The polarization direction was parallel to floor. Targets were natural elements (Pb, Au, Sn, Cu, Fe and Ti) whose thicknesses were from 1cm to 4 cm with 1 cm in diameter. The neutrons were detected by six neutron detectors, filled with NE213 liquid organic scintillator, placed at different angles (30 degrees to 150 degrees horizontally and 90 degrees vertically).

3. **Data analysis:** The data analysis process was reported in [1,2]. The DDXs were deduced normalizing the neutron spectrum with number of incident LCS photons and target atoms. In the obtained energy spectra, the evaporation and non-evaporation components were visibly distinguished at 4 MeV. The energy of 4 MeV was used to separate two components of the neutron spectrum at different angles. The angular differential cross section (ADXs) of evaporation and non-evaporation components were calculated, respectively, by integrating DDXs from the minimum energy to 4 MeV and 4 MeV to the maximum energy. The angular distribution of each component was determined by the fitting function, $ADX(\Theta)=a+b\cdot\cos(2\Theta)$.

4. **Results:** The angular distributions of evaporation and non-evaporation components for every target are discussed on b_{evap} and b_{evap}/a_{evap}, and b_{direct} and b_{direct}/a_{direct}, respectively. The b_{evap} is small in comparison with b_{direct} except for Ti target. The b_{evap}/a_{evap} for all targets are less than 0.09. This means the angular dependence of the evaporation components are isotropic. For the non-evaporation component, the b_{direct}/a_{direct} are more than 0.24 for all nuclei except Ti. The b_{direct}/a_{direct} of Ti is –0.35, and the angular distribution of non-evaporation component of Ti shows opposite one to the that of other targets. In general, the distribution of the non-evaporation component can be expressed well by $\cos(2\Theta)$.

[1] Tran Kim Tuyet et al., Presentation of 2M02, AESJ 2019 autumn at Toyama University Sep 11-13.
[2] Tran Kim Tuyet et al., Presentation of 2O06, AESJ 2020 spring at Fukushima University Mar 16-18.