PHOTON ABSORPTION ON A NEUTORON-PROTON PAIR IN ^{3}He AND ^{4}He

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Photodisintegration reactions of light nuclei have been studied for a long time both theoretically and experimentally. Since electromagnetic interaction is well known and the structure of the light nuclei is believed to be understood reasonably well, observables of these reaction are expected to be calculated correctly. Despite of this expectation, there still remains some descrepancies between experimental data and theoretical results, and it is very interesting to study these points.

Recently the photodisintegration cross sections of ^{3}He and ^{4}He were measured using real photon at intermediate energy region by TAGX group. They have obtained completely exclusive data by measuring all kinematical information in final states. We are interested in two features of the experimental data; (i) Energy dependence of the total cross section of ^{3}He(γ,pn)p_{sp} reaction is different from that of theoretical results at $E_\gamma \leq 200$MeV [1], and (ii) Total cross section of ^{4}He(γ,pn)d_{sp} shows steep energy dependence around $E_\gamma \sim m_\pi$ which has not been explained theoretically [2, 3].

In this report we study the ^{3}He(γ,pn)p_{sp} and ^{4}He(γ,pn)d_{sp} reactions theoretically using a phenomenological model and try to find possible origin of the discrepancies described above.

The cross section of ^{3}He(γ,pn)p_{sp} reaction is written as,

$$d\sigma = \frac{1}{\lambda^{1/2}(s,0,M^2_{^3He})} \mid T \mid^2 \frac{1}{(2\pi)^5}\delta^4(p_{sp}+p_p+p_n-p_{^3He}-p_\gamma) \times \frac{M_p^2 M_n M_{^3He}}{E_{p_{sp}}E_pE_n} d^3\mathbf{p}_{p_{sp}} d^3\mathbf{p}_p d^3\mathbf{p}_n, \tag{1}$$

and the cross section of ^{4}He(γ,pn)d_{sp} reaction as,

$$d\sigma = \frac{1}{\lambda^{1/2}(s,0,M^2_{^4He})} \mid T \mid^2 \frac{1}{(2\pi)^5}\delta^4(p_{d_{sp}}+p_p+p_n-p_{^4He}-p_\gamma) \times \frac{M_d M_p M_n M_{^4He}}{E_{d_{sp}}E_pE_n} d^3\mathbf{p}_{d_{sp}} d^3\mathbf{p}_p d^3\mathbf{p}_n. \tag{2}$$

In order to calculate these cross sections, we assume the quasi-deuteron mechanism for these photodisintegration processes. The effective T-matrix of γ absorption by ^{3}He and ^{4}He is written as,

$$\mid T_{He} \mid^2 = \mid T(\gamma pn \to pn) \mid^2 \mid \psi_{pn-spectator} \mid^2,$$

where T(γpn $\to$ pn) denotes effective T-matrix of γ absorption by pn pair, which is approximated by the experimental cross section $\left(\frac{d\sigma}{d\Omega}\right)$ of d(γ,p)n reaction [4] as;

$$\mid T \mid^2 = \frac{d\sigma}{d\Omega}\lambda^{1/2}(s,0,M_d^2)(2\pi)^2\frac{E_p+E_n}{M_pM_nM_d}\frac{1}{\mid \mathbf{p}_p \mid}. \tag{3}$$

We used Gaussian form for the relative wave functions between pn pair and spectator particle in ^{3}He and ^{4}He as follows;

$$\mid \psi_{pn-spectator} \mid^2 = N^2 \exp\left(-\frac{2p_{sp}^2}{p_f^2}\right), \tag{4}$$

where N is a normalization factor and p_f is treated as a parameter. In the calculation, we evaluate the final-state three-body phase space exactly.

We show numerical results in Fig. 1 and Fig. 2. As shown in Fig. 1, our model does not reproduce the energy dependence of the total cross section of ^{3}He(γ,pn)p_{sp} reaction at lower E_γ. In Fig. 2 we show a ratio of $\sigma(^4He(\gamma,pn)d_{sp})/\sigma(d(\gamma,pn))$ as a function of E_γ. Lines show calculated results with p_f=100, 200, 300, and 400MeV, respectively. These results do not reproduce the step-like change of the ratio $\sigma_{^4He}/\sigma_d$.

In summary, we have calculated the cross sections for the photodisintegration reactions ^{3}He(γ,pn)p_{sp} and ^{4}He(γ,pn)d_{sp} assuming the quasi-deuteron mechanism and compared the results with the experimental data. Our model reproduce gross features of the data but certain descrepancies remain. Especially, the step-like change of the ratio $\sigma_{^4He}/\sigma_d$ around π-production threshold could not be explained. To improve the model, we plan to develop a microscopic model of T-matrix and include the effects of final state interaction more correctly.

References

[1] P. Wilhelm, J. A. Niskanen, H. Arenhovel, Phys. Lett. B **335**, 109 (1994).
[2] K. Maruyama *et al.*, Phys. Lett. B **393**, 295 (1997).
[3] S. Endo, Journ. Sci. Hiroshima Univ. Ser. A **57**, 1 (1993).
[4] P. Rossi *et al.*, Phys. Rev. C **40**, 2412 (1989).
[5] T. Emura *et al.*, Phys. Rev. C **49**, 597 (1994).