Photodisintegration cross section of ^{4}He in the giant dipole resonance energy region

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Summary

Isovector Giant Dipole Resonance (IVGDR) is the most well examined collective excitation mode of atomic nuclei and is attributed to linear anti-phase oscillations of protons and neutrons. The IVGDR in various nuclei heave long been studied systematically via photonuclear reactions by means of various experimental probes and reactions including photodisintegration. Consequently, several properties of the IVGDR in heavy nuclear system are well explained from macroscopic models, but those in light nuclei are rather complicated due to the relative importance of individual nucleon degrees of freedom. Recently, ab initio calculations, which is a general framework based on realistic nuclear force, can give qualitative predictions on the nuclear reaction relevant to the IVGDR in light nuclei.

As for ^{4}He photodisintegration in IVGDR energy region, recent theoretical calculations concluded the IVGDR resonance peak should locate approximately at the E_γ =26 MeV in the excitation function [1]. On the other hand, the recent experimental results show a serious discrepancy in peak energies [2, 3, 4]. According to one of two doctrines, the IVGDR peak would be at E_γ >30 MeV, which even disagrees with the theoretical predictions. This striking result by Shima *et al.* [2] was constructed upon the robust experimental procedures and therefore may force knowledge regarding nuclear structure and nuclear astrophysics based on the current understanding on the nuclear force to be modified.

In the present work, we performed the simultaneous measurement of ^{4}He(γ, n)^{3}He and ^{4}He(γ, p)^{3}H reactions in the energy range around the IVGDR. Aiming to give a criteria to judge the origin of the experimental discrepancy, our measurement was conducted inheriting the experimental scheme adopted by Shima *et al.* [2]. Quasi-mono-energetic photon beams at E_γ = 23.0, 24.0, 25.0, 27.0, 28.0, and 30.0 MeV, were produced at BL01 [5] in the NewSUBARU synchrotron facility via the laser Compton scattering technique. The beam was irradiated on the MAIKo active target [6] time projection chamber filled with helium gas. The trajectories of charged decay particles emitted from ^{4}He were recorded and analyzed event by event. The fine-pitched readout and optimization of the

operating condition of the detector system improved the quality of the acquired data compared to the previous study.

The differential cross sections of the ^{4}He(γ, n)^{3}He and ^{4}He(γ, p)^{3}H reactions were computed from the experimental yields, the deduced detection efficiency, and the integrated beam flux. The angular dependence of the cross section was well explained from the assumption that the photodisintegration in this energy region was induced via pure $E1$ transition. The total cross section was evaluated assuming the $E1$ transition. Our data suggested ^{4}He(γ, n)^{3}He and ^{4}He(γ, p)^{3}H cross sections showed peak structures around E_γ = 26 MeV. This result contradicted the previous experimental study reported by Shima *et al.*[2], but was consistent with several theoretical calculations [1] and another experimental studies [3, 4]. We could conclude that the unconventional result was less likely to true, and there were no need to revise the conventional view on the nuclear physics.

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