Photodisintegration of ^{4}He near the threshold energy

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The photodisintegration reactions of ^{4}He in the giant-dipole-resonance (GDR) energy region is important for studies of the reaction mechanism, the charge symmetry of the nuclear force, and so on. However, the existing data are in severe contradiction with each other[1-13], and that is quite unsatisfactory for the above studies. Recently, Efros et al.[17] claimed the previous data and calculations[14,15,16] on the excitation function of ^{4}He in the GDR energy region are not consistent with the one expected from the E1 sum rule, and predicted the peak energy of the cross section to be about 30MeV, which is significantly higher than the previously adopted value of 25MeV. With the above situation it is quite crucial to determine the absolute cross sections of the ^{4}He photodisintegration reactions accurately. Therefore we have performed precise measurements of the cross sections[18], and most recently we have succeeded in measuring the ^{4}He(γ,p)^{3}H cross section near the threshold energy.

The experiment was performed at the Electrotechnical Laboratory (ETL). We used a Laser-Compton-Scattered (LCS) γ-ray[19] with the average energy of E_γ =21.4MeV as the incident γ-ray beam. We adopted a time projection chamber (TPC) filled with the gas mixture of He 80% and CD_4 20%. Therefore the TPC served as an active target, which provided the acceptance of 4π and the detection efficiency of about 100%. The overall sensitivity of the measurement was checked by measuring the D(γ,p)n reaction, whose cross section is known very accurately in the present energy range[20-23]. The intensity of the incident γ-ray was measured with a BGO scintillation counter, and the total irradiation was $(6.1\pm0.2)\times10^8$ photons. The target thicknesses of ^{4}He and D were 3.70 ± 0.04mg/cm^2 and 1.37 ± 0.015mg/cm^2, respectively. The γ-ray energy spread was measured with a NaI(Tl) scintillation counter, and was about 10%.

From the experiment the ^{4}He(γ,p)^{3}H reaction cross section at E_γ =21.4MeV was determined to be 0.19 ± 0.02(stat.)±0.01(sys.)mb. And the D(γ,p)n reaction cross section was obtained as 0.50 ± 0.05(stat.)±0.03(sys.)mb, which is in excellent agreement with previous data and theoretical calculations.

The present result is shown in Fig. 1 together with the results of our previous measurements at higher γ-ray energies. The obtained ^{4}He(γ,p)^{3}H cross section keeps increasing up to E_γ =32MeV, and that is completely different from most of the previous data and calculations. The shape of the obtained excitation function is similar to the one from the calculation by Efros et al., but the absolute value is lower by $\sim$30% than the calculation. We are now planning to measure the reaction cross section in the energy range from 30MeV to 100MeV in order to search for the missing γ-transition strength.

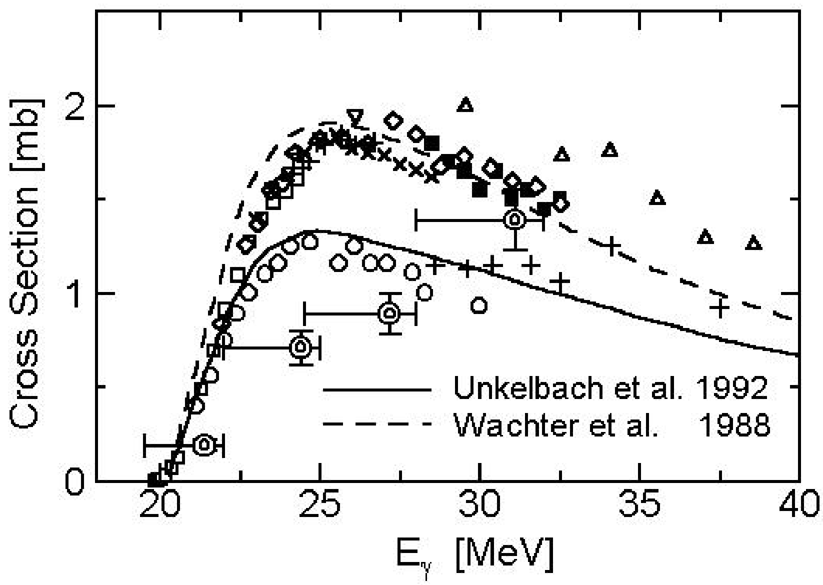

Figure 1: Excitation function of $^{4}He(\gamma,p)^{3}H$. Double circle; present, closed circle; Ref.10, open circle; Ref.11, closed square; Ref.12, open square; Ref.13, triangle; Ref.8, rev. triangle; Ref.9, diamond; Ref.3, cross; Ref.1, diag. cross; Ref.2. The solid line and the dashed line are the calculations by Ref.16 and Ref.15, respectively.

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