Photodisintegration of He^3 near the Threshold*

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(Received 1 July 1963)

The total cross section for the reaction He^3 (γ,p)D has been measured at gamma-ray energies of 6.14, 6.97, and 7.08 MeV. The cross section was found to be 0.102, 0.298, and 0.307 mb at the three energies. The experimental cross-section values are compared with those of the inverse reaction $D(p,\gamma)He^3$, as an accurate check on the principle of detailed balance.

THE photodisintegration of He^3 has been observed by Cranberg[1] and Berman *et al.*[2] This letter describes the measurement of the total cross section of the reaction $He^3(\gamma,p)D$ ($Q=-5.493$ MeV) at gamma-ray energies of 6.14, 6.97, and 7.08 MeV. The experimental cross-section values are compared with those of the inverse reaction as an accurate check on the principle of detailed balance.

The reaction was observed in a cylindrical, gridded ionization chamber of active volume 1.485 liters. The chamber contained 1.05 atm of He^3, 0.0187 atm of methane, and 1.36 atm of argon. The methane was added to reduce the resolving time of the chamber to less than 2 μsec, whereas the argon served as a stopping gas for the photodisintegration products. It was necessary to reduce the tritium contamination in the He^3 to eliminate the electron background due to the β decay of tritium. The tritium contamination was reduced from one part tritium per 10^5 parts He^3 to five parts tritium per 10^{10} parts He^3 by freezing the tritium at 4.2°K. The characteristics of the ionization chamber and the purification technique will be published in a separate communication.[3]

Two identical chambers were used in the experiment and were placed symmetrically on either side of the gamma-ray source. One chamber contained He^3, methane, and argon, the other contained He^4, methane, and argon. The outputs of the two chambers were fed through separate amplifying systems into separate halves of the memory of a model ND 103 Nuclear Data pulse-height analyzer. In this way, all effects not specific to the He^3 could be monitored. Elaborate wax and cadmium shielding was required to attenuate the thermal neutron background and thus reduce the capture of thermal neutrons by the He^3.

The gamma rays were produced by bombarding CaF_2 targets with protons accelerated by a 3 MeV Van de Graaff generator. Table I shows the relative yields and

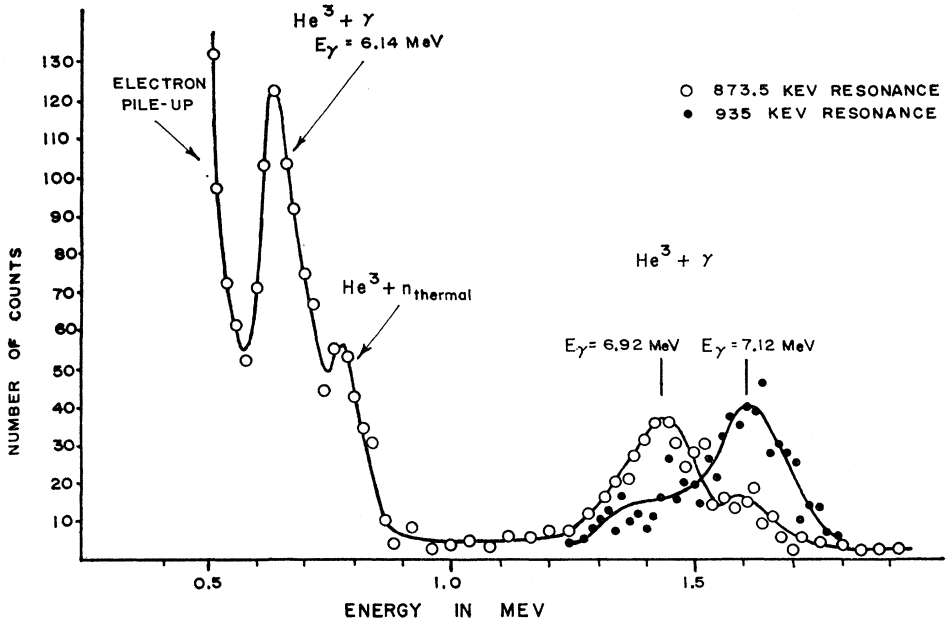

FIG. 1. Photodisintegration spectra.

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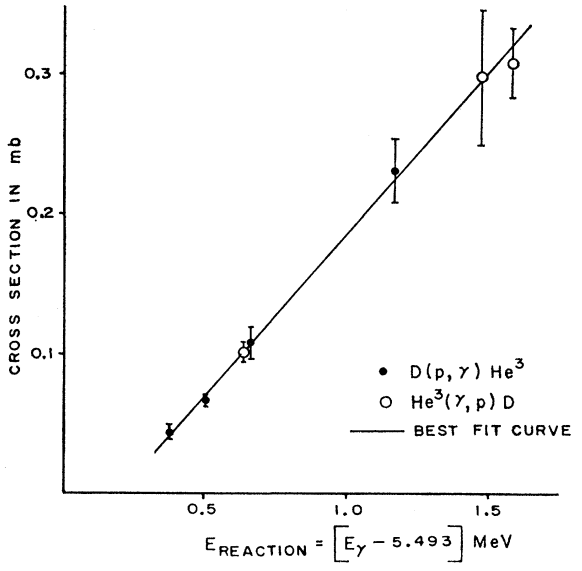

FIG. 2. Comparison of cross sections for the inverse reactions $He^3(\gamma,p)D$ and $D(p,\gamma)He^3$.

angular distributions of the gamma rays from the reaction $F^{19}(p,\alpha\gamma)O^{16}$ at the two proton bombarding energies used in the experiment.[4–6]

TABLE I. Relative yields and angular distribution of gamma rays.

E_{proton} (keV)	Relative gamma-ray yields 6.14 MeV	6.92 MeV	7.12 MeV	$p-\gamma$ angular distribution
873.5	73%	20%	7%	6.14 MeV $1-0.1\cos^2\theta$ 6.92 MeV $1+0.51\cos^2\theta-0.22\cos^4\theta$ 7.12 MeV $1+0.622\cos^2\theta$
935	75%	3%	22%	Isotropic at all energies

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TABLE II. Cross section for the reaction $He^3(\gamma,p)D$.

E_γ (MeV)	σ (mb)	Experimental error	Total probable error including uncertainties in relative gamma-ray yields
6.14 (873-keV resonance)	0.109	9%	14%
(935-keV resonance)	0.102	6%	7%
6.97	0.298	5%	16%
7.08	0.307	5%	8%

The gamma flux was measured with an accurately calibrated NaI(Th) scintillation counter. The efficiency for this counter had been previously measured by Griffiths, Larson, and Robertson[7] at a gamma-ray energy of 6.14 MeV.

The photodisintegration spectra at the two fluorine resonances are shown in Fig. 1. Below 1.2 MeV, the spectra from the two resonances are essentially identical. In calculating the cross sections at 6.92- and 7.12- MeV gamma-ray energies, no attempt was made to separate the peaks. Instead, the cross section is given in terms of a mean gamma-ray energy assuming the ratios of 6.92- and 7.12-MeV gamma rays as given in Table I, and taking into account the rate of change of cross section with change in gamma-ray energy. The experimental cross section values are shown in Table II.

The inverse reaction, $D(p,\gamma)He^3$, has been studied by several workers.[7–11] Figure 2 shows the results of the application of the principle of detailed balance to the experimental measurements of Griffiths.[11] The photodisintegration cross-section values are shown for comparison. The agreement is well within experimental error.

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