Laboratori Nazionali di Frascati

LNF-72/7

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Estratto da: Lett. Nuovo Cimento 3, 63 (1972)

LETTERE AL NUOVO CIMENTO VOL. 3, N. 2 8 Gennaio 1972

Two-Body Photodisintegration of ^{3}He with Linearly Polarized Gamma-Rays.

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(ricevuto il 22 Novembre 1971)

In this letter we present some preliminary results on the study of the reaction

$$\gamma + {}^3\text{He} \to \text{p} + \text{d} \tag{1}$$

with linearly polarized gamma-rays.

We have measured the asymmetry parameter at 90° in the c.m.s. and at gamma-ray energies between 180 and 300 MeV. The measured value is indicated in column 1 of Table I and in Fig. 1.

TABLE I. – *Experimentally measured values of the asymmetry parameter and the calculated polarization of the gamma-ray beams.*

E_γ (MeV)	$A/90°$ c.m.s.	Photon polarization	
		First run	Second run
170÷190	-0.41 ± 0.10	0.24 ± 0.01	—
190÷210	-0.40 ± 0.06	0.32 ± 0.01	0.20 ± 0.01
210÷230	-0.35 ± 0.05	0.40 ± 0.01	0.25 ± 0.01
230÷250	-0.28 ± 0.05	0.46 ± 0.01	0.31 ± 0.01
250÷270	-0.31 ± 0.07	—	0.38 ± 0.01
270÷290	-0.28 ± 0.07	—	0.44 ± 0.01

The hypothesis that the reaction is dominated by an electric-dipole transition implies that the asymmetry is equal to minus one and is clearly inconsistent with our data.

The cross-section for two-body photodisintegration of ^{3}He has been calculated with different models. Most models reproduce the cross-section at low energy. No model pretends to be valid very well at high energy around and above the pion threshold.

Some recent models tend to include only the transitions indicated in Fig. 2 [1]. The lower E_1 transition is the dominant one, while the M_1 and E_2 transitions from an $S_{\frac{1}{2}}$-state are the other more relevant contributions. There is no interference between E_1

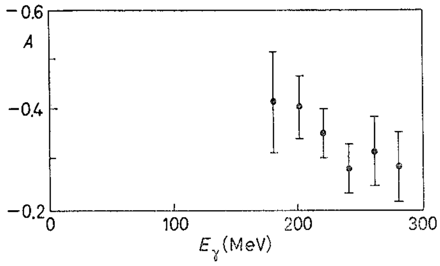

Fig. 1. – The asymmetry parameter A from Table I: $A = (d\sigma_\perp - d\sigma_\parallel)/(d\sigma_\perp + d\sigma_\parallel)$, $\gamma + {}^3He \to p + d$, $\Theta^* = 90°$ c.m.s.

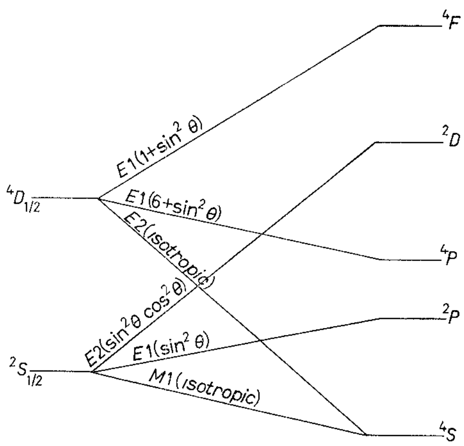

Fig. 2. – The lower-order electromagnetic transitions contributing to our processes with an indication of their respective contributions to the angular distributions of the reaction products.

and M_1 because they lead to final state with different spin. At 90° in the c.m.s. E_2 does not contribute. Under this hypothesis the asymmetry parameter, defined in the usual way, is given by

$$A = \frac{d\sigma_\perp - d\sigma_\parallel}{d\sigma_\perp + d\sigma_\parallel} = -\frac{b_e}{a_m + b_e} = -\frac{1}{1 + a_m/b_e},$$

where

$d\sigma_\parallel$ is the differential cross-section at 90° in the c.m.s. measured in the plane of linear polarization of the gamma-ray beam,

$d\sigma_\perp$ is the differential cross-section at 90° in the c.m.s. measured in the plane perpendicular to the plane of polarization of the gamma-ray beam,

b_e is the contribution to the cross-section from the E_1 transition,

a_m is the contribution to the cross-section from the M_1 transition.

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[1] H. Book: Thesis (1969), unpublished.

It is clear from this formula that the asymmetry parameter A gives directly, under our simple assumptions, the partial contribution of the electric-dipole transition to the cross-section.

To perform our measurement we have used the partially polarized gamma-ray beam produced by the coherent bremsstrahlung of electrons in a diamond crystal (2) and the liquid helium target described in ref. (3). The detection apparatus consists of a NaI(T_1) crystal and two thin plastic scintillators in the deuteron channel. The proton telescope had four plastic scintillators and aluminium absorbers. The bidimensional analysis of the pulses in the NAI crystal and the plastic scintillator in front of it permit the identification and the counting of the deuterons emitted in coincidence with a proton on the other side of the target.

The data have been collected in two separated runs with a different inclination of the crystal axes with respect to the beam line and therefore a different gamma-ray spectrum. The calculated polarization of the gamma-ray beams used in this experiment are indicated in columns 3 and 4 of Table I. The points taken in the two runs were statistically consistent and have been combined to produce Table I.

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It is a pleasure to thank Prof. G. Bologna for his invaluable help in the calcultion of the polarization of the coherent bremsstrahlung beam. Mr. C. Carocci contributed with physical insight, intelligence and personal sacrifice to the experiment.

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(2) G. Barbiellini, G. Bologna, G. Diambrini and G. P. Murtas: *Phys. Rev. Lett.*, **9**, 396 (1962).
(3) I. Modena, V. Montelatici and F. Scaramuzzi: *Nucl. Instr. and Meth.*, **44**, 175 (1966).