Triton Reaction Cross Sections*

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(Received April 25, 1958)

Measurements of the D$(t,\alpha)n$ reaction cross section at triton energies of 1.9 and 1.5 Mev have been made to resolve a disagreement among previously published values. Corrections for published values of the $He^4(t,t)He^4$ and T(t,t)T scattering cross sections are also suggested.

INTRODUCTION

RECENT measurements of differential cross sections of the T$(d,n)He^4$ reaction[1,2] are in marked disagreement with D$(t,\alpha)n$ results.[3] Since the equipment described in the preceding paper[4] is well suited for studying the interactions of tritons with gaseous targets, it was decided to make a measurement of the D$(t,\alpha)n$ cross section at several points in order to resolve this disagreement. Measurements[5] were made at laboratory angles of 30° and 60° for triton bombarding energies of 1.9 and 1.5 Mev. Cross sections of the elastic scattering processes $He^4(t,t)He^4$ and T(t,t)T were also determined[5] for comparison with other results[6,7] obtained with essentially the same equipment as used in reference 3.

APPARATUS AND EXPERIMENTAL METHOD

The equipment and method used were the same as described in reference 4 except for some modifications in the use of the magnetic spectrometer. The slit system at the entrance of the spectrometer was adjusted such that the included angle was only 6 minutes of arc. The two-body nature of the reactions studied and the small acceptance angle of the spectrometer slit system limited the energy spread of the particles entering the spectrometer to the extent that it was possible to focus all the particles on the detecting crystal with the slit over the crystal removed. That is, there was a region of spectrometer magnet current where the number of counts was constant and equal to the total yield for the given solid angle. A typical counting rate curve is shown in Fig. 1. The cross sections were then computed from the formula

$$\sigma(\theta) = Y \sin\theta / NnG,$$

where Y is the yield as determined from the flat top of the observed counting rate curves; θ is the laboratory angle; N is the particle density of the target gas; n is the number of incident tritons giving Y; and G is the geometrical factor (see reference 4).

Experimental tests were made with p-p scattering and the results were within 1.4% of the values reported by Worthington *et al.*[8] Other checks were made with Coulomb scattering of protons and tritons by argon and krypton.

RESULTS AND DISCUSSION

The results are given in Table I. The counting statistics were always less than 1.2%. Other errors are similar to those of reference 4 and are all less than 1%. A conservative estimate of the total standard deviation for values reported in this paper is 3%.

Also given in Table I are the data of references 1, 3, 6, and 7. The accuracy of the data of reference 1 is quoted as 5% while that of references 3, 6, and 7 is quoted as 3%. It is clear that the present results agree with the T$(d,n)He^4$ values of reference 1 and are about 20% lower than the values reported in references 3, 6,

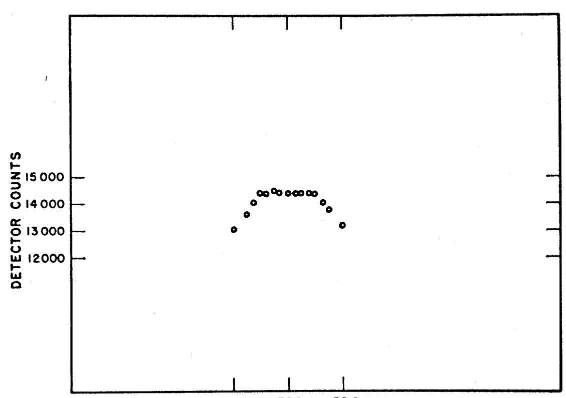

FIG. 1. Typical counting rate curve as described in the text. This particular case is for p-p scattering at 30°(lab) for 1.90-Mev protons. The statistical error of a point is about the size of the point.

* Work performed under the auspices of the U. S. Atomic Energy Commission.

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TABLE I. Triton cross sections.

Reaction	θ_{lab} (degrees)	E_t (Mev)	$\sigma(\theta)_{lab}$ (mb/sterad)	$\sigma(\theta')_{cm}$ (mb/sterad)	Other results (mb/sterad)	Difference (%)
$He^4(t,t)He^4$	30	1.677	875	...	1060[a]	21
$T(t,t)T$	30	1.900	286	...	343[b]	20
$T(t,t)T$	30	1.800	287	...	328[b]	15
$D(t,\alpha)n$	30	1.900	...	15.7	16.0[c]	1.9
$D(t,\alpha)n$	60	1.900	...	15.0	15.4[c]	2.6
$D(t,\alpha)n$	30	1.500	...	20.0	20.6[c]	3.0
					24.2[d]	21
$D(t,\alpha)n$	60	1.500	...	19.6	20.0[c]	2.0
					23.1[d]	18

[a] See reference 6. [b] See reference 7. [c] See reference 1. [d] See reference 3.

and 7. After discussions with the experimenters of the latter references, who all used essentially the same equipment, it appears that a systematic error in their experiments involving the collection of the triton beam could explain the discrepancies, and that their absolute values are probably around 20% high. The slight angular distribution discrepancies between references 1 and 3 are not resolved by the present work.

ACKNOWLEDGMENTS

We are very grateful for many discussions with S. J. Bame, A. Hemmendinger, H. V. Argo, and D. M. Holm.

PHYSICAL REVIEW VOLUME 111, NUMBER 4 AUGUST 15, 1958

Possible Experiments for Determination of Beta Interactions. II*†

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(Received April 10, 1958)

In Part I of this series we have proposed some possible recoil experiments to decide the relative strength of scalar and vector interactions and that of tensor and axial vector interactions in beta decay. The formulas in the analysis of these experiments have been given for decays involving beta-gamma cascades and K-capture gamma-gamma cascades. Here, similar formulas are given for decays involving beta-gamma-gamma cascades, taking into account the nuclear resonance fluorescence and circular polarization of the gamma ray. The decay of Co^{60} is discussed in detail. The degree of the circular polarization of the resonant gamma ray from Ni^{60} is 2% left-handed if the beta interaction is axial vector and 23% right-handed if tensor.

1. INTRODUCTION

IN the previous paper,[1] we have proposed thirty-three possible experiments to decide the relative strength of scalar and vector interactions and that of tensor and axial vector interactions in beta decay. For all the proposed experiments, it is necessary to measure the recoil of the nucleus directly or the nuclear resonance fluorescence caused by a gamma ray which follows the beta decay or K capture. Ten of the thirty-three experiments involve beta-gamma and K-capture gamma-gamma cascades. Formulas for the analysis of these ten experiments have already been given in I. In this paper, we derive formulas for the other possible experiments listed in Appendix II of I. The formulas are derived in a manner described in I. We restrict our problem to the angular correlations[2] of the beta ray, the first gamma ray, and the resonant gamma ray, in decays involving the beta-gamma-gamma cascades. The relative intensity of the resonant gamma rays, which is useful in the analysis of the circular polarization of the resonant gamma ray, is also given. Explicit formulas for angular correlations of the nuclear recoil, the beta ray, and the two gamma rays may be obtained by a similar calculation. We shall consider measurements of the nuclear resonance fluorescence (or resonant scattering of nuclear gamma ray) and the circular polarization of gamma rays, but not of the polarization of beta rays. Furthermore, formulas will be derived for allowed beta transitions alone.

* Part I of this paper has been published by Morita, Morita, and Yamada, Phys. Rev. **111**, 237 (1958).
† This work partially supported by the U. S. Atomic Energy Commission.
‡ On leave from Kobayasi Institute of Physical Research, Kokubunzi, Tokyo, Japan. Ernest Kempton Adams Fellow of Columbia University.
[1] Morita, Morita, and Yamada, Phys. Rev. **111**, 237 (1958), referred to hereafter as I. *Erratum:* In that paper, in the first line of Eq. (1), $F(Z,E)$ should read $F(Z,E)pEq$.

[2] Both directional and polarization correlations. Here, polarization means polarization of gamma rays only.