that the activity cannot be distributed both uniformly and only in the gas phase as assumed in the derivation of Eq. (1), and therefore indicates a possible error in the experimental ratio. However, it was noted that the L/K-capture ratio was independent (within $\pm 4\%$) of variations in several experimental parameters, such as the pressure and type of the Zn^*R_2, the pressure of P-10, the type of liner in the counter, and the length of time the activity was in the counter, e.g., successive ratios were found to be constant (to $\pm 2\%$) in counting periods, which were about 0.7–2 h, in which 3–4 K peaks alternating with 2–3 L peaks were recorded. Therefore, some degree of confidence in the accuracy of the ratio is felt in spite of the varying activity.

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β-γ Circular-Polarization Correlation in the Decay of Mn^{52}

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The β-γ circular-polarization correlation in the decay of Mn^{52} has been measured by means of Compton forward scattering. The constant A was found to be $A=0.00\pm0.02$ which implies a value of $x=-0.08\pm0.03$ for the ratio between Fermi and Gamow-Teller contributions to the decay (standard deviations). This result is in agreement with theoretical estimates.

I. INTRODUCTION

THE measurement of the circular polarization of gamma radiation following an allowed beta decay has been of great interest in the last few years because it directly indicates the ratio between Fermi and Gamow-Teller contributions to the decay.[1–22] According to the isotopic-spin selection rule,[23] this ratio should be zero in all cases of practical interest as long as the isotopic spin itself is a good quantum number. The experimental results, however, are somewhat conflicting. Older experiments[1–8,10,12,15] seem to indicate large Fermi contributions (about maximum interference terms) in many cases, while most of the recent experiments[13,16–18,20–22] show smaller or even vanishing Fermi contributions for light- or medium-weight nuclei.

In the case of Mn^{52}, Boehm[6] first measured a large positive ratio between Fermi and Gamow-Teller contributions. Later Boehm[22] gave a smaller but still

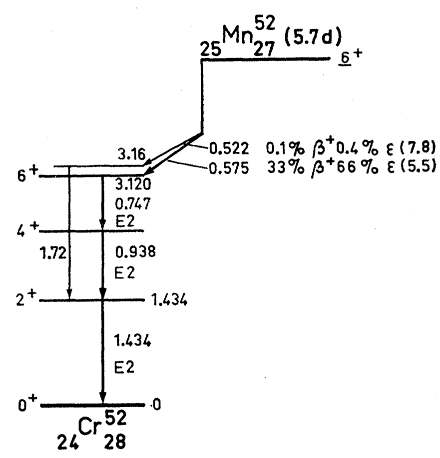

FIG. 1. Disintegration scheme of Mn^{52}.

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TABLE I. Summary of earlier and present results.

Method	A	$x = C_V M_F / C_A M_{GT}$	Author
Circular polarization	-0.16 ± 0.05	$+0.15 \pm 0.08$	Boehm[a]
	-0.10 ± 0.03	$+0.06 \pm 0.04$	Boehm[b]
	-0.089 ± 0.028	$+0.05 \pm 0.04$	Bloom *et al.*[c]
	0.00 ± 0.02	-0.08 ± 0.03	present work
Oriented nuclei		-0.048 ± 0.006	Ambler *et al.*[d]
		-0.035 ± 0.006	Postma *et al.*[e]
Theory		-0.04	Kelly and Moszkowski[f]
		-0.07	Bouchiat[g]

[a] See reference 6. [b] See reference 22. [c] See reference 20. [d] See reference 24. [e] See reference 25. [f] See reference 27. [g] See reference 28.

positive value. Bloom, Miskel, and Mann[20] found a small positive or vanishing value for this ratio. Ambler *et al.*[24] determined the ratio to be small, but negative, and definitely different from zero. The latter authors measured, among other quantities, the directional distribution of electrons emitted from oriented nuclei. In the same way Postma *et al.*[25] measured a small but not vanishing negative Fermi contribution. Figure 1 gives the decay scheme[26] of Mn^{52}.

With certain assumptions calculations may be performed which indicate to what extent the isotopic-spin selection rule is or may be violated. In the case of Mn^{52}, Kelly and Moszkowski[27] give a value of -0.04 for the ratio between Fermi and Gamow-Teller contributions while Bouchiat[28] gives this ratio as -0.07. It should be mentioned that both calculations, although not in complete agreement, lead to a small Fermi contribution. Table I contains the results of the earlier work, both experimental and theoretical, and the result of the present work.

It was the purpose of the present work to measure the beta-gamma circular-polarization correlation of Mn^{52} accurately enough to be able to distinguish between a small positive Fermi to Gamow-Teller ratio, a vanishing ratio, or a small negative ratio.

II. EXPERIMENTAL PROCEDURE AND RESULTS

Mn^{52} was produced by the reaction $Cr^{52}(d,2n)Mn^{52}$ at 10.9 MeV in the Heidelberg cyclotron. The chemical separation to extract the manganese activity involved oxidation of the chromium and manganese with H_2O_2 in an alkaline medium and centrifugation of the remaining MnO_2. After dissolving in HCl the procedure was repeated several times in order to remove any adsorbed chromium.

Two sources were prepared, each by evaporation to dryness. The circular polarization of the gamma radiation was detected by means of Compton forward scattering. The experimental setup and procedure have already been described.[9,15,17] As calibration standards, Co^{60} and Na^{22} were chosen. The β threshold was chosen to be 61 keV, the γ threshold 150 keV. The random coincidences never exceeded 3% while the γ-γ coincidences amounted to 16% of the total coincidence counting rate. Table II gives the results for the two Mn^{52} sources. The combined result for the constant A of the circular-polarization correlation is

TABLE II. Results of the present measurements.

Source No.	$10^4(N_+ - N_-)/(N_+ + N_-)$ (raw value)	A (with all corrections)	$x = C_V M_F / C_A M_{GT}$
1	0.4 ± 4.6[a]		
2	-0.2 ± 2.3[a]		
Average		0.00 ± 0.02[b]	-0.08 ± 0.03[b]

[a] Standard deviation of counting statistics.
[b] Standard deviation including calibration error and uncertainty due to possible source-thickness effects.

$$A = 0.00 \pm 0.02.$$

The stated error is the standard deviation including calibration error and uncertainty due to possible source thickness effects. Figure 2 shows the plot[29] of A vs x for $(V-A)$ interaction,[24,30–42] x being the ratio between Fermi and Gamow-Teller contributions. Experimental points showing the results of earlier work as well as the present work are indicated. With $A = 0.00 \pm 0.02$, x is

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found to be

$$x = -0.08 \pm 0.03.$$

III. DISCUSSION

The result of the present investigation is in excellent agreement with the work of Ambler, Hayward, Hoppes, and Hudson.[24] Although the measured ratio between Fermi and Gamow-Teller contributions to the decay is small, it is definitely negative and not zero. This is completely in accordance with the theoretical expectations,[27,28] and with the conserved vector current concept.[43–47] Large interference terms, however, would not fit well in this concept. This question has been discussed extensively by Bouchiat.[28]

The observation of the *small* but not vanishing Fermi-Gamow-Teller interference term for Mn^{52} agrees well with recent experiments[17,18] on Sc^{46}, V^{48}, Co^{56}, and Ag^{110m} performed in this laboratory.

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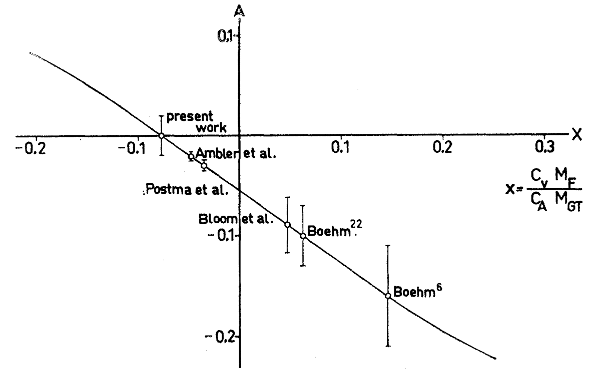

FIG. 2. A vs x, $x = C_V M_F / C_A M_{GT}$ being the ratio between Fermi and Gamow-Teller contributions to the decay. The results of Ambler *et al.* (reference 24) and Postma *et al.* (reference 25) are drawn as if obtained with the β-γ circular-polarization correlation.

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$Li^6(d,p_1)Li^{7*}$ Reaction at 2-MeV Bombarding Energy

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Absolute differential cross sections and reduced widths have been obtained for the reactions $Li^6(d,p_0)Li^7$ and $Li^6(d,p_1)Li^{7*}$.

THE angular distributions from the reactions $Li^6(d,p)Li^7$ and $Li^6(d,p_1)Li^{7*}$ have been determined using deuteron energies up to 3 MeV by several investigators.[1–6] Absolute differential cross sections are quoted in only three cases,[1,4,5] in two of which the values differ by approximately a factor of 10.

The $F^{19}(d,p)F^{20}$ reaction has been investigated at a bombarding energy of 2 MeV, using a target of LiF of natural isotopic content.[7] The spectrum of protons, which included those from the $Li^6(d,p)Li^7$ reaction, was analyzed by a broad-range magnetic spectrograph and recorded in nuclear emulsions. The method of analysis of the results has been described previously.[7]

The angular distribution of $Li^6(d,p_1)Li^{7*}$ was determined over the angular range 5 to 115° lab. Since this experiment was secondary to that of $F^{19}(d,p)F^{20}$, the proton group from $Li^6(d,p_0)Li^7$ was not observed at angles less than 55° lab because it lay outside the energy range of the instrument at forward angles. This partial angular distribution is not shown here.

The relative angular distribution of $Li^6(d,p_1)Li^{7*}$ is given in Fig. 1, the ordinate scale being the same as that of the groups from $F^{19}(d,p)F^{20}$.[7] The errors on the points are the combined statistical errors arising from counts in the spectrograph and monitor groups. This angular distribution is similar in form to that given by Nickell[6]

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