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Brief Reports

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Magnetic electroexcitation of the 0.478 MeV state in ^{7}Li at low momentum transfer

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Five form factor values for the 0.478 MeV transition in ^{7}Li have been measured at $\theta = 180°$ in the momentum-transfer range, $0.4 < q < 0.75$ fm^{-1}, using a Li_2S target. These data will complement measurements recently taken on this transition at $q > 0.8$ fm^{-1} by other investigators. Comparison is made with theoretical calculations. A value of the ground-state transition width $\Gamma_0(M1) = (7.5 \pm 1.7) \times 10^{-3}$ eV is found for this transition in agreement with earlier measurements of other workers.

[NUCLEAR REACTIONS ^{7}Li (e,e'), $E_0 = 40$–74 MeV; measured $d\sigma/d\Omega$ at $\theta = 180°$; deduced form factors and transition width Γ_0.]

The significance of high-momentum-transfer (high-q) electron scattering data in the study of such effects as meson exchange currents has been considerably emphasized in recent years.[1–3] Such effects have been especially important in understanding the shape and amplitude of the form factor curves of light nuclei in the region beyond the second maximum. Measurements of the form factor extending to high-q values have been made by Bergstrom *et al.*[4] for the transition to the 3.56 MeV 0^+ state in ^{6}Li, and more recently for the 0.478 MeV transition in ^{7}Li by Lichtenstadt *et al.*[5]

Nevertheless, there is a continuing need for low-q data which provide an accurate anchoring of the form factor curve, so that the high-q data can be more fully exploited. Low-q data can also be of value in determining a more accurate model-independent value of the ground-state transition width. Early work on the form factor for the transition to the 0.478 MeV $\frac{1}{2}^-$ state in ^{7}Li was reported[6] covering a range of about $0.3 < q < 0.9$ fm^{-1}. It is the purpose of the present high resolution study to determine more accurately the low-q portion of the form factor curve.

In the present experiment targets of natural Li_2S (92.5% ^{7}Li and 95% ^{32}S), about 33 mg/cm^2 thick were exposed to the beam from the Bates-MIT electron accelerator. Five runs were taken at a 180° scattering angle and at incident electron energies ranging from 40 to 74 MeV. A Li_2S target was used since the present measurements were auxiliary to the principal experiment[7] designed to study transitions to excited states in ^{32}S. The details of the Li_2S target fabrication, handling, installation, and beam exposure procedure are given in Ref. 7.

The measured cross sections were obtained using an interactive curve-fitting program[8] which determined the area of each peak in the spectra using the minimum χ^2 technique. The data were then corrected for the Schwinger and bremsstrahlung radiation effects, and for ionization loss straggling effects. The cross sections were measured relative to those for the 3.56 MeV ^{6}Li $M1$ transition, which have been measured with considerable accuracy by Bergstrom *et al.*[4]

Figure 1, which shows the spectrum observed for 60 MeV incident electrons scattered at 180°, illustrates the quality of the data. The resolution, limited by target thickness, was about 2×10^{-3}. The sulphur and lithium elastic peaks and the ^{7}Li 0.478 MeV inelastic peak are statistically very well defined and easily amenable to curve-fitting techniques. Spectra of comparable quality were obtained at the other four incident electron energies. The values of the cross sections for the 0.478 MeV excitation at each incident electron energy are presented in Table I. Uncertainties given are due to base line location resulting from radiation tails and general background, line shape variations, counting statistics, and target thickness variations

From these cross sections, values for the square of the total form factor $\sigma/\sigma_{\text{Mott}}$ were obtained, where

$$\sigma_{\text{Mott}} = (Z\alpha/2E_0)^2 \cos^2(\theta/2)/\sin^4(\theta/2) \quad . \qquad (1)$$

TABLE I. Values of cross section and transverse form factors squared for the 0.478 MeV transition in ^{7}Li. The % errors apply to both cross section and the form factor squared. F_C is the Coulomb correction factor given by Ref. 10.

E_0 (MeV)	θ (deg)	q (fm^{-1})	$d\sigma/d\Omega$ (fm^2/sr) $\times 10^{-6}$	$10^{-4}F_T^2$	f_C	Error %
40.21	180	0.402	2.34	0.820	0.931	12.9
43.27	180	0.433	2.58	1.05	0.985	13.8
50.46	180	0.505	1.75	0.970	1.03	7.9
60.08	180	0.601	1.34	1.05	1.11	8.8
74.41	180	0.743	0.786	0.954	1.17	14.5

Since the data were taken at 180°, the values of the form factor squared, given in Table I, are essentially transverse, i.e., F_T^2. The experimental values of F_T^2 for the 0.478 MeV transition are shown in Fig. 2. They also connect well with the preliminary lower q values of Lichtenstadt *et al.*

It will be noted in Fig. 2 that the data are in excellent agreement with the theoretical curve given by Dubach *et al.*,[9] who use an oscillator shell model calculation with Cohen and Kurath wave functions. Meson exchange effects are not taken into account in the calculation of this curve. However, at the low-q values characteristic of this experiment, meson exchange effects are not expected to be important. The theoretical curve includes both an $M1$ and a transverse $E2$ component. For the highest experimental momentum-transfer value shown in Fig. 2, the $E2$ contribution is calculated[9] to be approximately an order of magnitude less than the $M1$, and becomes even less at lower momentum transfers.

Since Coulomb distortion effects should be small for ^{7}Li, it was considered adequate, in relating the experimental cross sections to the corresponding expressions in the plane wave Born approximation, to use the Coulomb correction factors given by Chertok *et al.*[10] Values of $[B(M1,q)]^{1/2}$ were then extracted from the corrected experimental cross sections and plotted versus q^2. By extrapolating the curve fitted to

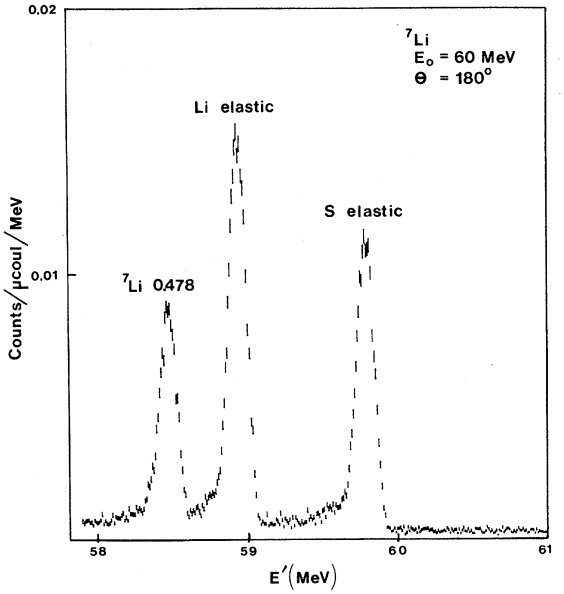

FIG. 1. Spectrum of 60 MeV incident electrons scattered at 180° from Li_2S. The abscissa is scattered electron energy.

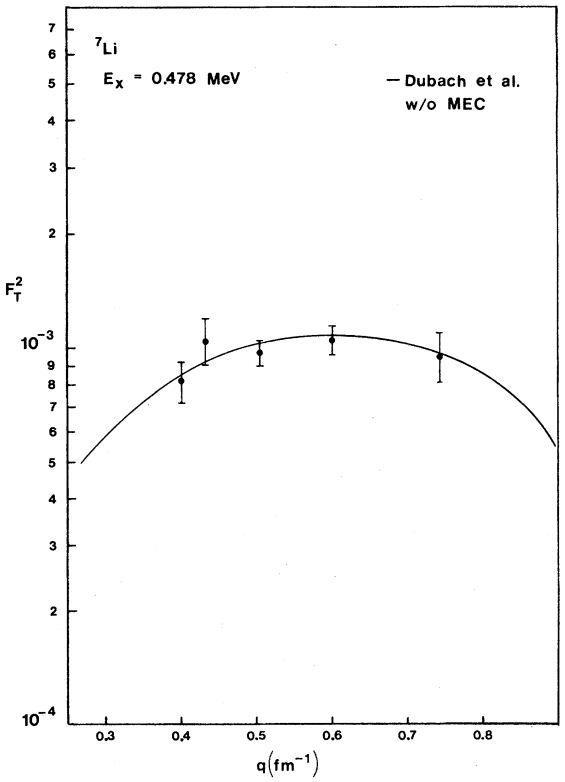

FIG. 2. Transverse form factor squared F_T^2 vs momentum transfer, q for the 0.478 MeV transition in ^{7}Li. The solid curve is from the theoretical calculation of Ref. 9 without inclusion of meson exchange effects.

these values to $q = \omega$, the excitation energy, a value of $B(M1, \omega) \approx B(M1, 0)$ could be obtained. A value of the ground-state transition width, $\Gamma_0(M1) = (7.5 \pm 1.7) \times 10^{-3}$ eV was thus determined from our data in agreement with that of $= (6.3 \pm 0.31) \times 10^{-3}$ eV found by Van Niftrik *et al.*[6]

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