NOTIZEN

An Investigation of the 5.36 MeV Level in ^{6}Li by Electron Scattering

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The form factor for the excitation of the 5.36 MeV level in ^{6}Li has been measured in a momentum transfer region $q=0.3 \div 1.8\ \mathrm{fm}^{-1}$. Calculations of this form factor were performed with L−S coupled intermediate-coupling shell model wave functions.

The form factor for the electron scattering excitation of the 5.36 MeV level in ^{6}Li has been measured at the Darmstadt and Mainz electron accelerator facilities in complementary momentum transfer regions

$$q=0.3 \div 0.6\ \mathrm{fm}^{-1} \quad \text{and} \quad q=0.7 \div 1.8\ \mathrm{fm}^{-1},$$

respectively. The 5.36 MeV level has positive parity [1], isospin $T=1$ and in this paper we have assumed it to have spin $J=2$ in agreement with most theoretical calculations [2, 3].

An excitation energy of 5.38 ± 0.02 MeV and a natural level width of 530 ± 30 keV were extracted from the spectra. An example of a high-momentum transfer spectrum is shown in Fig. 1. The value of the excitation energy is in good agreement with the compilation of LAURITSEN and AJZENBERG-SELOVE [4]. Our value for the width, although disagreeing radically with the compilation, is in good agreement with the recent measurements of COCKE [5] who used the ^{7}Li(^{3}He,α)^{6}Li reaction.

Because the level width influences the determination of the inelastic cross section, the low-momentum transfer data [6] were re-analyzed with our improved width. It should be noted that both the Darmstadt and Mainz spectra were treated in a consistent way [6, 7].

From the ratios of the inelastic and elastic peak areas and the elastic cross section given by the Stanford measurements [8], the inelastic cross sections, $d\sigma/d\Omega$, were determined. The low-momentum transfer angular distributions indicate that the form factor is dominantly transverse [6], and therefore we have neglected any possible longitudinal contributions. In first Born approxi-

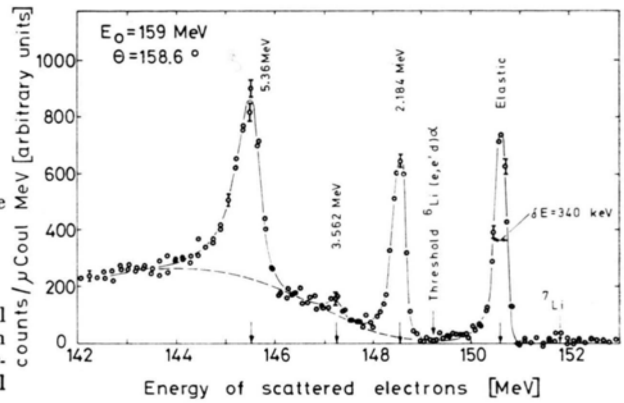

Fig. 1. ^{6}Li spectrum, taken at a backward angle. The elastic momentum transfer is $1.54\ \mathrm{fm}^{-1}$, the elastic cross section $0.893 \cdot 10^{-33}\ \mathrm{cm}^2$/sterad. The experimental background has been subtracted. The broad distribution under the levels is produced by transitions to continuum nucleus final states (electrodisintegration).

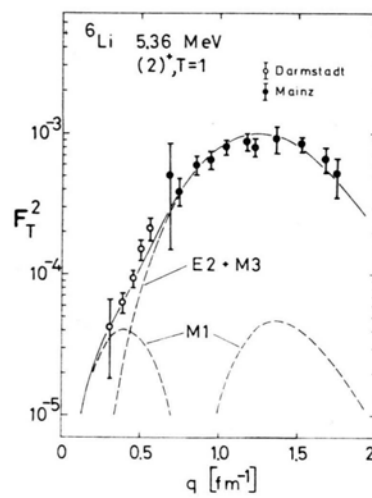

Fig. 2. Squared form factor for the excitation of the 5.36 MeV level. Measurements at equal momentum transfer [6] were combined to form single points. The solid line is the sum of the calculated M1, E2, M3 contributions to the form factor using the parameters of set I.

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mation the cross section for a transverse excitation is written in the form

$$\mathrm{d}\sigma/\mathrm{d}\Omega = (\mathrm{d}\sigma/\mathrm{d}\Omega)_{\mathrm{Mott}}(\tfrac{1}{2} + \tan^2 \Theta/2)\, F_{\mathrm{T}}^2(q)\,,$$

where $(\mathrm{d}\sigma/\mathrm{d}\Omega)_{\mathrm{Mott}}$ is the Mott cross section including the recoil term, Θ the scattering angle and $F_{\mathrm{T}}(q)$ is the transverse form factor. With this formula the values of the form factor were deduced from the measured inelastic cross sections. They are plotted in Fig. 2 against momentum transfer. The error bars on the individual points include statistical and systematic errors, where the systematic error in fitting the base line under the peak dominates.

Because the ground state has $J^{\pi} = 1^+$ and the excited state is assumed to have $J^{\pi} = 2^+$, only three multipolarities (M1, E2, M3) can contribute to the transition. Thus the squared form factor may be expressed through

$$F_{\mathrm{T}}^2 = F_{\mathrm{M1}}^2 + F_{\mathrm{E2}}^2 + F_{\mathrm{M3}}^2\,.$$

We have performed calculations of the form factor for this transition with L − S coupled intermediate-coupling shell model wave functions.

The radial wave functions were generated in a smoothed finite oscillator potential [9] which has been found to yield the measured form factor for the pure M1 transition to the 3.56 MeV level [7] in ^{6}Li. We have simply regarded the potential to be relative to the center of mass of the nucleus, and have not made the usual center-of-mass correction to the model. A gaussian electromagnetic density distribution for the nucleon ($\langle r^2 \rangle^{1/2} = 0.8$ fm) was, however, folded into the model.

The wave functions for the ground state and 5.36 MeV state were taken to be of the form

$$\Psi_{\mathrm{gs}} = \alpha\, {}^3\mathrm{S}_1 + \beta\, {}^1\mathrm{P}_1 + \gamma\, {}^3\mathrm{D}_1\,,$$
$$\Psi_{\mathrm{ex}} = \delta\, {}^3\mathrm{P}_2 + \varepsilon\, {}^1\mathrm{D}_2\,,$$

where α is known to be approximately unity [3].

The amplitudes of the various admixtures were determined by fitting to the data and requiring that, at the same time, the ground state wave function reproduces the measured quadrupole moment ($Q = -0.08$ fm^2). This second restriction fixes the ratio $|\beta/\gamma|$ and requires that γ be positive [10]. As can be seen from the theoretical curves on Fig. 2, the M1 contribution can be neglected in the momentum transfer region of about 1 fm^{-1}. Thus this region was used to fit the E2, M3 contribution which is primarily dependent upon ε. The value of ε determined in this manner yields automatically the magnitude of δ because of the normalization condition ($\delta^2 + \varepsilon^2 = 1$). This leaves the sign of δ undetermined. The fitting of the M1 contribution at low momentum transfer then yields a second relation between β and γ, and in addition the requirement that β and δ have the same sign.

Two sets of parameters yielding equally good fits are obtained:

I.	$\alpha = 0.995$	$\beta = 0.065 \pm 0.020$	$\gamma = 0.024 \pm 0.003$
		$\delta = 0.625 \pm 0.050$	$\varepsilon = 0.780 \pm 0.060$
II.	$\alpha = 0.995$	$\beta = -0.080 \pm 0.030$	$\gamma = 0.025 \pm 0.003$
		$\delta = -0.730 \pm 0.060$	$\varepsilon = 0.685 \pm 0.055$

The theoretical form factors obtained from set I are shown in Fig. 2. The form factors calculated with these two sets of parameters were extrapolated to the photon point and the γ-ray decay width for each of the multipolarities was determined. For the M1 decay to the ground state we obtained

$$\Gamma_{\gamma}{}^0(\mathrm{M1}) = 0.19 \pm 0.04\ \mathrm{eV} \qquad \mathrm{(I)}$$

and

$$\Gamma_{\gamma}{}^0(\mathrm{M1}) = 0.08 \pm 0.04\ \mathrm{eV}, \qquad \mathrm{(II)}$$

respectively, where no corrections have been applied to the Born approximation. As the E2, M3 decay widths are negligibly small compared to the M1 width, the total $\Gamma_{\gamma}{}^0$ is given effectively by $\Gamma_{\gamma}{}^0(\mathrm{M1})$.

On the basis of the present experiment it is not possible to decide between the two sets of parameters and their associated γ-ray widths. However, this would be possible through a measurement of the sign of the P state admixture in the ground state or excited state. Barker [3] has performed intermediate coupling calculations for ^{6}Li, in which the wave functions were determined by fitting the energies of known levels. He obtained a positive sign for δ and therefore the first set of parameters seems to be favoured.

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