## Low-Energy Electron Scattering from the 2.18 and 3.56 MeV Levels of $^6$Li

F. Eigenbrod

Institut für Technische Kernphysik
der Technischen Hochschule Darmstadt

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From inelastic electron scattering cross sections, measured for momentum transfers $q$ between 0.21 and 0.56 fm$^{-1}$, ground state radiative widths [$(4.31 \pm 0.34) \cdot 10^{-4}$ eV for the 2.18 MeV E2 transition] and transition radii have been deduced.

Using the facilities of the Darmstadt 60 MeV linear accelerator [1], electrons with energies from 30 to 58 MeV were scattered through 93° to 165° from a 95.6% enriched $^6$Li target. With a new 20-detector system [2], counting rates were obtained with a statistical accuracy better than 1%.

Fig. 1 shows a typical spectrum. The peak at $E_x = 2.18$ MeV corresponds [3] to the E2 transition $1^+ \rightarrow 3^+$; the peak at $E_x = 3.56$ MeV to the M1 transition $1^+ \rightarrow 0^+$. The peak areas were evaluated by means of a computer program [4] which fits the inelastic lines with the elastic line shape. Inelastic cross sections were determined relative to the elastic ones which, in turn, were calculated by partial wave analysis [5] with parameters obtained from measured elastic cross sections [6].

From the cross sections of the 2.18 MeV transition, Born approximation (B.A.) reduced transition probabilities $B(C2, q)$ have been deduced. The deviations from the B.A. were taken into account using correction factors calculated [7] by partial wave analysis. The power series [8], valid for low $q$,

$$B(C2, q)^{1/2} = B(C2, 0)^{1/2} \left(1 - \frac{1}{14} q^2 R_{tr}^2 + \frac{1}{504} q^4 R_{tr}^{*4}\right), \quad (1)$$

with

$$R_{tr}^2 = \langle r^{\lambda+2} \rangle_{tr} / \langle r^\lambda \rangle_{tr},$$

$$R_{tr}^{*4} = \langle r^{\lambda+4} \rangle_{tr} / \langle r^\lambda \rangle_{tr},$$

and

$$\lambda = 2,$$

was fitted to the corrected experimental data (see Fig. 2). The accuracy of the measurements allowed $B(C2, 0)$, $R_{tr}^2$ and $R_{tr}^{*4}$ to be fitted independently. From the value $B(C2, k)$ where $k = E_x/\hbar c$, the ground state radiative width $\Gamma_\gamma^0$ is obtained.

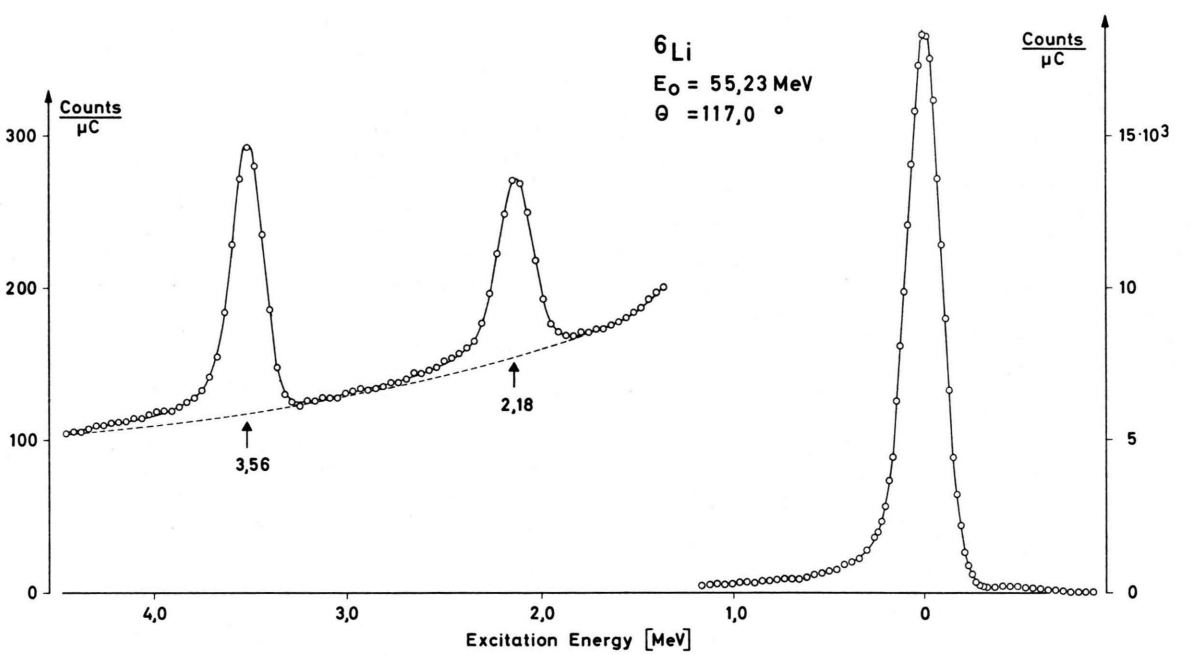


Fig. 1. Energy distribution of 55.23 MeV electrons scattered from a 165 mg/cm$^2$ $^6$Li target through 117.0°. The full curve shows the computer fit to the inelastic spectrum. The background is given by the dashed curve.

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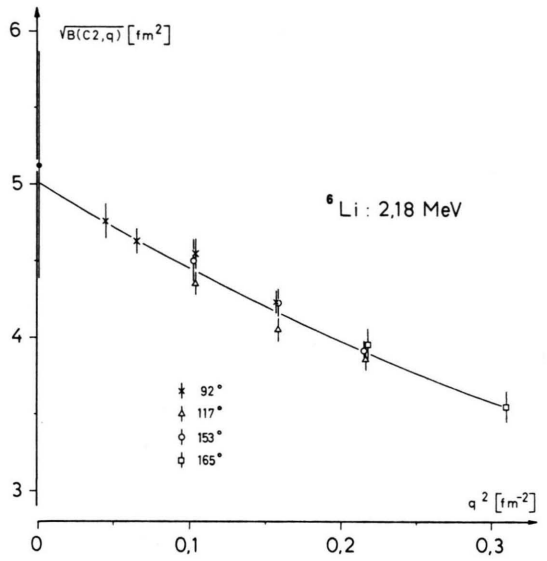


Fig. 2. Square roots of the reduced transition probabilities for the 2.18 MeV transition in $^6$Li as a function of $q^2$. The curve fits the experimental points, obtained at different scattering angles, with arbitrary parameters $\Gamma_\gamma{}^0$, $R_{tr}$ and $R_{tr}{}^*$. For comparison, the full point is the value taken from the $^4$He(d,$\gamma$)$^6$Li experiment [9].

The results are listed in Table 1. The value of $\Gamma_\gamma{}^0$, which corresponds to $B(C2, k\uparrow) = (25.1 \pm 2.0)$ fm$^4$, agrees with that of WAHL [9] recently measured using the reaction $^4$He(d,$\gamma$)$^6$Li. The present value, however, is more accurate and should be used for comparison with calculations.

Agreement between Hartree-Fock calculations of BOUTEN et al. [10] and our data has been achieved by fitting an oscillator length parameter $b = (1.96 \pm 0.03)$ fm as compared with the value 1.60 fm proposed by the authors to obtain the minimum in the $^6$Li binding energy. The calculated ratio $R_{tr}{}^*/R_{tr}$ which is independent of $b$ is in good agreement with the experimental value.

For the M1 transition at $E_x = 3.56$ MeV the correction factors which account for the deviations from the B.A. are less certatin, because those for C2 (instead of M1) were used as a reasonable approximation [11]. For $B(M1, q)$, an expansion similar to Eq. (1), but with coefficients $\frac{1}{5}$ and $\frac{3}{280}$ instead of $\frac{1}{14}$ and $\frac{1}{504}$, and $\lambda = 1$, was fitted to the data. The results of the three parameter are shown in Table 1.

| $E_x$ (MeV) | 2.184 | 3.562 |
|---|---|---|
| $\Gamma_\gamma{}^0$ (eV) | $(4.31 \pm 0.34) \cdot 10^{-4}$<br>$(4.5 \pm 1.3) \cdot 10^{-4}$ a | $8.35 \pm 0.37$<br>$7.52 \pm 0.43$ c<br>8.4 calc. d |
| $R_{tr}$ (fm) | $4.10 \pm 0.63$ | $2.81 \pm 0.18$ |
| $R_{tr}^*$ (fm) | $4.5 \pm 1.4$ | $2.8 \pm 1.6$ |
| $R_{tr}^*/R_{tr}$ | $1.1 \pm 0.4$<br>1.06 calc. b | $1.0 \pm 0.6$<br>1.12 calc. e |

Table 1. Ground state radiative widths $\Gamma_\gamma{}^0$ and transition radii $R_{tr}$ and $R_{tr}{}^*$ of the 2.18 and 3.56 MeV states of $^6$Li. a) ref. [9]. b) ref. [10]. c) from WAHL et al. cit. in ref. [12]. d) ref. [13]. e) ref. [14].

Here, the ($\gamma$,$\gamma$) value of WAHL et al. [12] has comparable accuracy, but is lower by 10%. Whether part of this discrepancy can be attributed to the estimate used for the M1 correction factors is still an open question. This will be discussed in the final paper which is planned for publication in Zeitschrift für Physik.

A comparison with intermediate-coupling shell-model calculations [13, 14] shows that the value of $\Gamma_\gamma{}^0$ agrees with the predicted one of BARKER [13]. The present value of $R_{tr}{}^*/R_{tr}$ is in good agreement with that deduced from KURATH's results [14]. In fitting his reduced transition probability formula to our data one gets an oscillator length parameter of $(2.03 \pm 0.04)$ fm.

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