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THE $T = 0$ ^6Li LEVELS AT $E_x = 4.31$ AND 5.65 MeV

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Introduction.

The question if the spectroscopic parameters of light nuclei are dependent on the way used to deduced them is still open [1]. In fact while the theoretical predictions of the above question are beyond the present capability the experimental results generally show a certain dependence on: i) bombarding energy; ii) detecting geometry; iii) reaction used to populate the state of interest.

Recently in three previous works [2-4] by performing kinematically complete experiments, we studied the excited ^6Li level at $E_x = 5.65$ MeV. At first, using the $^7Li(^3He, \alpha d)\alpha$ reaction, we populated the above $J^\pi = 1^+$, $T = 0$ ^6Li level at the incident ^3He energies of 2.5, 5.0 and 11.5 MeV [2-3]. In table 1 we reported the Γ width values of the level of our concern as deduced by experimental data. As one can see in the energy range between 2.5 and 11.5 MeV the Γ $(^6Li_{5.65})$ does not appear to depend, within the measurement errors, on the bombarding energy. Later always with a $^7Li(^3He, \alpha d)\alpha$ kinematically complete experiment performed at $E(^3He) = 5.0$

MeV, we demonstrated (see table 1) that the above width was independent from the revelation geometry too [4]. In the three experiments [2-4], the deduced $\Gamma(^6Li_{5.65})$ values were in line with the one adopted in literature [1].

Table 1 - Γ width values of the $^6Li_{5.65}$ lelvel deduced by a $^7Li(^3He, \alpha d)\alpha$ experiments.

E_{in} (MeV)	Γ (keV)	Ref.	θ_α=90° θ_α (degree)	E_{in}=5.0 MeV Γ(keV)	Ref.
2.5	1700± 300	2	35	1700±250	4
5.0	1600±300	2	40	1500±250	4
11.5	1600±300	3	50	1750±250	4
values adopted	1500±200	1	70	1700±250	4
in literature			80	1650±250	4

An analogue result was obtained by studying the excited ^6Li level $J^\pi = 2^+$, $T = 0$ at $E_x = 4.31$ MeV. In fact by the analysis of the $d\alpha$ bidimensional spectra coming from the $^7Li(^3He, \alpha d)\alpha$ reaction performed at 2.5, 4.0, 5.0 and 6.0 MeV [5-6], it is show that the $\Gamma(^6Li_{4.31})$ values are independent from the bombarding energy and in line with the value adopted in literature [1]. The results are summarized in table 2.

With this state of affairs we decided to investigate on the iii) point. Thus we populated the excited $^6Li_{4.31}$ and $^6Li_{5.56}$ levels performing a $^6Li(p, p\alpha)d$ kinematically complete experiment at. 11.4 MeV incident proton energy detecting the proton alpha coincidences.

Table 2 - Γ width values of the $^6Li_{4.31}$ lelvel deduced by a $^7Li(^3He, \alpha d)\alpha$ experiments.

θ_α=60° E_{in} (MeV)	θ_d=120° Γ(keV)	Ref.
2.5	1600± 300	5
4.0	1600±200	6
5.0	1700±200	6
6.0	1500±200	6
values adopted in literature	1700±200	1

The experiment.

The experiment was performed at the isochronous cyclotron of the Institute for Nuclear Research of Kiev. The beam entered the scattering chamber passing through collimating circular diaphragms and was stopped in a Faraday cup after bombarding the target. This latter was made by vacuum evaporation of LiF (enriched in ^6Li to 99.9%) onto a 30 $\mu g \cdot cm^{-2}$ carbon backing and its thickness was about $100 \mu g \cdot cm^{-2}$.

In order to detect the $p\alpha$ coincidences we used a $\Delta E_1 - E_1$ telescope and a E_2 detector. The telescope, consisting of a surface barrier detector ΔE_1 (20 μm thick) and a totally depleted surface barrier detector E_1 (1000 μm thick), was used to detect the protons. The E_2 (300 μm thick) detector was a totally depleted surface barrier detector used to detect the α-particles.

The position of the two detectors ($\theta_p = 130°$, $\phi_p = O°$ and $\theta_\alpha = 35° = \phi_\alpha = 180°$), on the opposite side with respect to the beam, were chosen to obtain a region of spectrum with the two

^6Li contributions of our interest only.

We measured the energy of both $p-$ and $\alpha-$ particles and the time-of-flight difference by means of a standard fast-slow electronic set-up. The calibration of the energy pulses of the detector chains (ΔE_1, E_1 and E_2) was obtained by the 5.48 MeV α-particles emitted from a ^{241}Am source put inside the scattering chamber and of a pulse generator. Spurious coincidences were reduced to a very low level by selecting off line a 10 ns window for the time-of-flight difference of the coincidence events.

Successively all the events of the $p\alpha$ spectrum were corrected for the loss of energy in target and projected onto the $p + \alpha + d$ kinematical locus by a standard technique [3-7-8].

Results and discussion.

Figure 1 shows the $p\alpha$ event distribution in the relative coordinate system (RCS), versus the $E_{\alpha-d}$, obtained using the appropriate Jacobian of the $LS \rightarrow RCS$ transformation.

As one can see one well defined peak, contributed from both $T = 0$ ^6Li levels $J^\pi = 2^+$ at 4.31 MeV and $J^\pi = 1^+$ at 5.65 MeV, appears. Here the error bars represent only the statistical error. No contribution from the two ^6Li levels at $E_x = 3.56$ and 5.37 MeV are expected because the first γ decay only while for the second one the αd decay channel is isospin forbidden.

Now, in order to separate the two above contributions and to extract their widths, we assumed that:

a) the interference effects can be neglected;
b) in the RCS each contribution can be represented by a Lorentian distribution;
c) the positions are the ones given in literature.

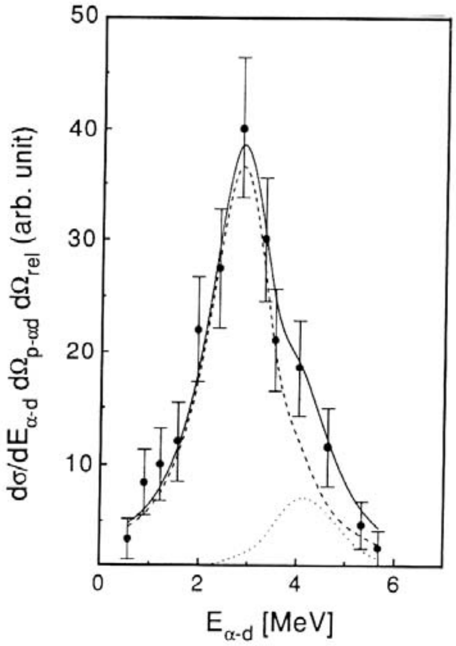

Fig. 1. Differential cross-section versus relative energy of the $\alpha - d$ system for the $^6Li(p, p\alpha)d$ reaction at $E_p = 11.4$ MeV, $\theta_p = 130°$, $\phi_p = 0°$, $\theta_\alpha = 35°$ and $\phi_\alpha = 180°$. The dashed line represents the $^6Li_{4.31}$ contributions. The dotted line represents the $^6Li_{5.65}$ contributions. The solid line is the sum of these contributions as result of the fitting procedure.

In this way, with a least-square method realized by an incoherent sum of the two Breit-Wigner functions, we fitted the data [9-10]. In fact, using the $E_x = 4.31$ and 5.65 MeV values for the $J^\pi = 2^+$, $T = 0$ and $J^\pi = 1^+$, $T = 0$ excited ^6Li levels, respectively, with an autoconsistent calculation we obtained the yields of the two contributions and this widths: $\Gamma(^6Li_{4.31}) = 1650 \pm 200KeV$ and $\Gamma(^6Li_{5.65}) = 1600 \pm 200KeV$.

The estimate of these errors takes into account both the statistical errors and the finite energy resolution of the electronic system used. In fig. 1 the two above ^6Li contribution levels are reported too.

As one can see, both the values are in line with the ones deduced by us [2-6] using other reactions, revelation geometries and incident energies.

This result is not surprising because we believe that many geometries-, energies- and kind of reactions-dependence are wrong effects due to the interference effects, when present, and to the analysis method used [11]. Often it is sufficient to estimate correctly the errors to remove the above dependence. Howewer we can state that the two above ^{6}Li level of our interest in all the experiments performed by us appear energy-, geometry- and reaction-independent.

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