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THE CHARACTERISTIC OF THE FIRST EXCITED STATE OF ^{5}Li (*)

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SUMMARY

The analysis of the αα bidimensional spectrum for $\vartheta_1 = 50°$, $\varphi_1 = 0°$ and $\vartheta_2 = 90°$, $\varphi_2 = 180°$ of the $^{6}Li(^{3}He,\alpha p)\alpha$ reaction at $E_{^{3}He} = 1.7$ MeV is a suitable way of calculating the excitation energy and width of the first excited state in the ^{5}Li nucleus. The deduced values are: $E_x = (5.0 \pm 0.6)$ MeV and $\Gamma = (5.8 \pm 0.6)$ MeV.

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In a recent work[1] some of us et al. have studied the ^{6}Li ($^{3}He,\alpha p)\alpha$ reaction at incident energy 1.7 and 2.3 MeV in order to deduce the excitation energy and width values of the first excited ^{5}Li state.

The results found for this state $\left[E_x = (5.0 \pm 0.7)\ \text{MeV},\ \Gamma = (5.7 \pm 0.7)\ \text{MeV}\right]$ are placed in the large spectrum of the values existing in literature[2-7], ranging from about 2 to 10 MeV for the excitation energy and from 1.5 to 9.0 MeV for the width. On the other hand, by using the ^{6}Li ($^{3}He,\alpha)^{5}Li$ reaction at $E_{^{3}He} \simeq 1.6$ MeV Vignon et al.[3] found for the excitation energy of the above state the value of 7.5 MeV while Gagne et al.[4] at $E_{^{3}He} = 1.8$ MeV found the values of (3.2 ± 0.2)MeV for the excitation energy and (1.5 ± 0.5) MeV for the width.

Due to the fact that a non-strictly sequential mechanism for this reaction used in the above-mentioned experiments does not appear to be a possible interpretation to clear up the discrepancies among the reported parameters,we think,as we have remarked in a previous paper[8], that these discrepancies can be imputable to the main error sources:

a) the too long data accumulation time;

b) the low resolving time of the coincidence circuit used to perform the experiment;

c) the data projection method.

In fact,in the experiment from which we have deduced the experimental result mentioned above[1] we have tried to keep these errors to a minimum.

Since no significant difference appears in the experimental results when the solid detectors angles are increased from 1 to 2 msr, in order to reduce the measurement time, we have used the largest of the detector solid angles tested.

The resolving time of the coincidence circuit was about 30 ns and the background was reduced to a very low level so that no correction to the data was necessary for it.

The best way of treating the bidimensional spectrum data is to project them onto an axis or a curve of the (E_1,E_2)- plane. There are various reasons which indicate that the central kinematic curve (the one corresponding to the angles defined by the beam direction and detectors axes) is a good choice as a projection locus. Actually both the finite angular and energetic resolutions of the detecting system contribute to the spreading of the events of the (E_1,E_2)-plane. Therefore,if the true distribution of events is to be extracted from the projected data,the geometrical effects have to be separated from the energetic ones before projecting them.

Obviously this is not necessary when the angular resolution is good with respect to the

energetic one. In such a case all the events can be considered as belonging to the central kinematic curve and it is correct enough to project all of them on such a curve. This condition is best satisfied in our experiment at $\vartheta_1 = 50°$ and $\vartheta_2 = 90°$ detector angles.
The data projection method,on the other hand,can lead to a strong deformation of the spectra projected,if the projection locus is not appropriately chosen. The same occurs if a suitable redistribution of the data on the projection locus is not carried out,in order to deconvolute them from the effects of the detecting-system finite resolving power.
By assuming that the finite overall energetic resolution of the detecting system produces a Lorentzian spreading, the method[8], while projecting the data,automatically operates the deconvolution of them from the effects due to the finite energy resolving power of the experimental apparatus.Thus it produces a distribution of the events on the kinematic curve which should be a good approximation with the true one.
In this work we have maintained the same experimental conditions used in the previous one[1],concerning beam energy,geometry of the detectors and resolving time coincidence circuit; instead,we have used a thinner target without however increasing the time of the run.
In such conditions the energy resolving power proves to be rather improved,even if the statistic results are lower. We have chosen not to change the other experimental condi - tions in order to carry out a true comparison between the recent results and those previously[1] obtained.
With this in mind,we thought it interesting to study the $^{6}Li(^{3}He,\alpha p)\alpha$ reaction at incident energy $E_{^{3}He} = 1.7$ MeV and a target with 30 $\mu g/cm^2$ in ^{6}Li thickness instead of 50 $\mu g/cm^2$ thick previously[1] used.
Fig.1 is a sketch of the experimental apparatus. The 1.7 MeV ^{3}He beam was produced by the

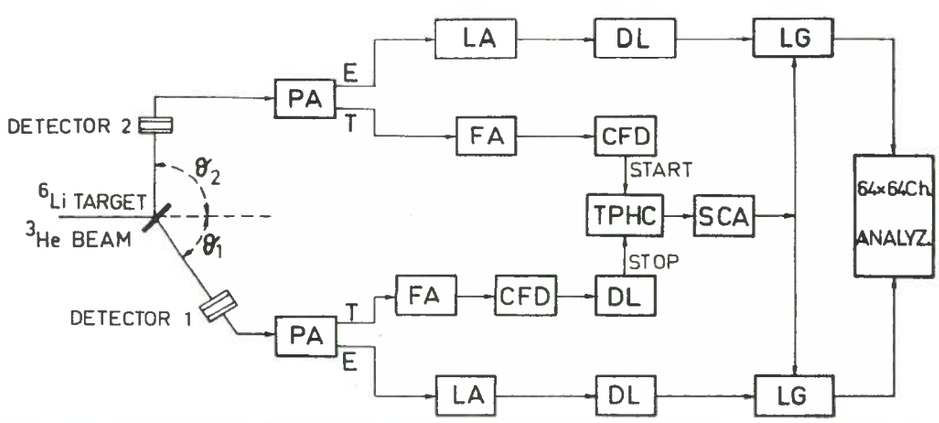

Fig.1 -Sketch showing the experimental apparatus

2.7 MV Van de Graaf accelerator of the CSFN/SM in Catania. The Li target was obtained by evaporating LiF (99,9% enriched in ^{6}Li) onto a carbon backing of 30 $\mu g/cm^2$. The two 100 μm thick surface barrier detectors were placed at $\vartheta_1 = 50°$, $\varphi_1 = 0°$ and $\vartheta_2 = 90°$, $\varphi_2 = 180°$, respectively. The chosen detector thickness, while being enough to stop all the α-particles, allowed all protons to pass. This, by allowing us to discriminate the α-particle pulses from the proton ones, prevented the detection of the αp coincidences and left out this last contribution from the spectral region of our interest. As fig.1 shows, the linear pulses to be analyzed were sent to the x and y inputs of a 4096-channel analyzer through two linear gates. These were gated by the pulses developed at the output of a TPHC/SCA system when the timing signals applied to its input occurred within a 30 ns time. Fig.2 shows the αα bidimensional spectrum measured after projecting the data onto the

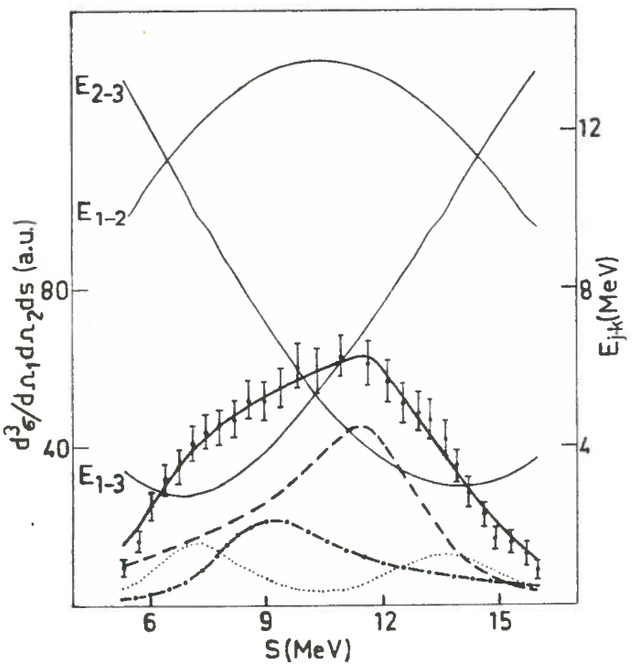

Fig.2 - Distribution of counts along the kinematic curve at $\vartheta_1 = 50°$, $\varphi_1 = 0°$ and $\vartheta_2 = 90°$, $\varphi_2 = 180°$ for the ^{6}Li(^{3}He,αp)α reaction at $E_{^3He} = 1.7$ MeV. Dotted line: ^{5}Li ground-state total contribution. Dashed line: ^{5}Li first-excited state contribution when the first emitted α-particle goes to detector 1. Dash-dotted line: ^{5}Li first-excited state contribution when the first emitted α-particle goes to detector 2. Solid line: total sum of the contributions resulting by the fit. The curves E_{1-2} and E_{1-3}, E_{2-3} refer to the relative energy of the αα and pα systems, respectively. s in the arc length of the rectified kinematic curve.

kinematical curve by the method which we used in our previous works[1,9,10] and after target energy loss corrections had been carried out. As the $E_{2-3}(s)$ and the $E_{1-3}(s)$ show, the decays of the g.s. and first excited state of the ^{5}Li contribute to this spectrum, while the products of the decay of the 11.4 MeV ^{8}Be (4^{+}) state are not present. These products could also contribute to the spectrum as the values of the $E_{1-2}(s)$ show. As a matter of fact,high spin of the above state and low bombarding energy prevent a significant formation of this state[11,12].

In order to extract the contributions of the first-excited state from the g.s. one of ^{5}Li, we make the hypothesis of neglecting the contributions of the interference effects.

We began with the assumption that each contribution could be represented in its own relative mass centre system (RCS) by a Lorentzian form,so in the laboratory system (LS)this contribution is

$$(J_{i-jk})^{-1} \cdot \frac{C_x \Gamma^2}{(E^{*} - E_{j-k})^2 + (\Gamma/2)^2}$$

here J_{i-jk} is the transformation LS-RCS Jacobian, Γ is the RCS state width,E_{j-k} its excitation energy and C_x a normalization constant.

To fit the experimental results we have used the MINUIT code assuming for E^{*} and Γ of ^{5}Li g.s. the values known in literature[13]. In this way,the code performs a consistent calculation and gives the values of the constant C_x,width Γ and position E^{*} of the first excited state of the ^{5}Li.

The contribution of this last state consists of two peaks corresponding to the values of (7.0 $\pm$ 0.6) MeV for the αp relative energy of the αp system and to the value of (5.8 $\pm$ 0.6) MeV for its width. Therefore,by assuming for the ^{5}Li g.s. excitation energy the value of 1.97 MeV,our estimate for excitation energy of the first excited state in the ^{5}Li nucleus is $E_x \doteq$ (5.0 $\pm$ 0.6) MeV.

Although these results are in perfect agreement with the ones previously found[1] by us and they are in strong disagreement with the ones reported by other authors[3,4,7] who studied our same reaction,we think that the mentioned discrepancies cannot be interpreted in terms of a non strictly sequential mechanism for the ^{6}Li(^{3}He,αp)α reaction,but they are attributed to the method of analysis of the data and to interference effects.

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