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SEQUENTIAL MECHANISM FOR THE $^{7}Li(^{3}He,\alpha)^{6}Li(d)\alpha$ REACTION AT INCIDENT ENERGY BETWEEN 2.5 AND 11.5 MeV.

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ABSTRACT

A strictly sequential mechanism appears to be appropriate for the $^{7}Li(^{3}He,\alpha)^{6}Li(d)\alpha$ reaction in the energy range between 2.5 and 11.5 MeV. It can be described by a first direct emission mechanism and a second delayed emission.

Recently, some of us et al. studied the $^3He + {^7Li} \rightarrow \alpha+\alpha+d$ reaction at incident energies of 2.5, 5.0 and 11.5 MeV(1-3). The analysis of the bidimensional spectra of deuterons and α-particles allowed us to:

i) deduce the absolute values of the differential cross sections and give information concerning the competition between the various $(d, {^8Be_{g.s.}})$, $(d, {^8Be}(3.04\ MeV))$ and $(\alpha, {^6Li}(5.65\ MeV))$ reaction channels when the incident energy was 5.0 MeV(2);

ii) verify if the Γ value of the ^6Li(5.65 MeV) measured at incident energies of 2.5 and 5.0 MeV(1) coincided with the value measured at 11.5 MeV(3).

In this report the authors deal with the reaction mechanism of the $^7Li(^3He,\alpha)^6Li(d)\alpha$ reaction in an incident energy range between 2.5 and 11.5 MeV.

Figures 1, 2 and 3 show bidimensional spectra of particles respectively at 2.5, 5.0 and 11.5 MeV energies. The spectra show the decay contributions which are kinematically possible for some of the ^6Li and ^8Be states which formed in the intermediate state of the above-mentioned reaction, while there was no trace of a simultaneous break-up.

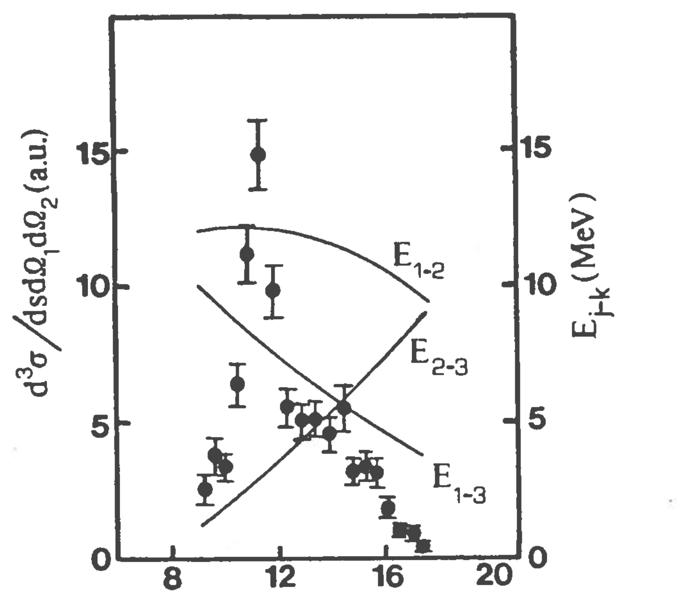

Fig.1.- Distribution of the $d\alpha$ coincidences along the rectified central kinematical curve vs. curvilinear abscissa s for the $^7Li(^3He,\alpha\alpha d)$ reaction at $\vartheta_1=90°$, $\varphi_1=0°$ and $\vartheta_2=45°$, $\varphi_2=180°$ and $E(^3He)=$ 2.5 MeV. The curves E_{1-2}, E_{1-3} and E_{2-3} refer to the relative energy of the $d\alpha$ and $\alpha\alpha$ systems, respectively.

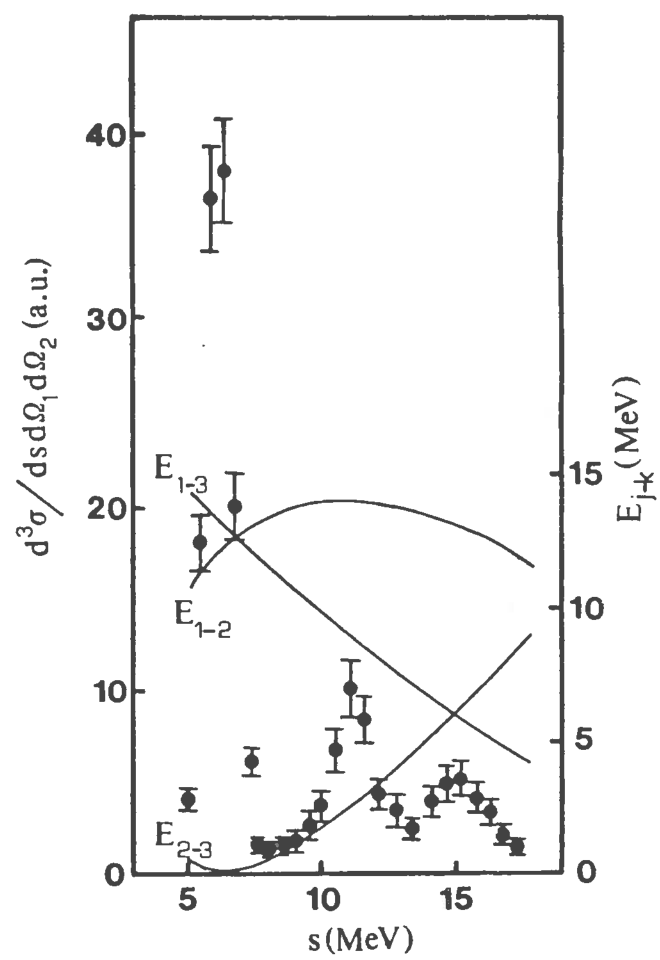

Fig.2.- Same as Fig.1 but with $E(^3He)$ = 5.0 MeV.

The contribution of the above-mentioned states were separated by making the hypothesis that each of them could be represented by Lorentzian form in the Relative Coordinate System (RCS) and that the total contribution could be obtained as an incoherent sum of the contributions of the single states.

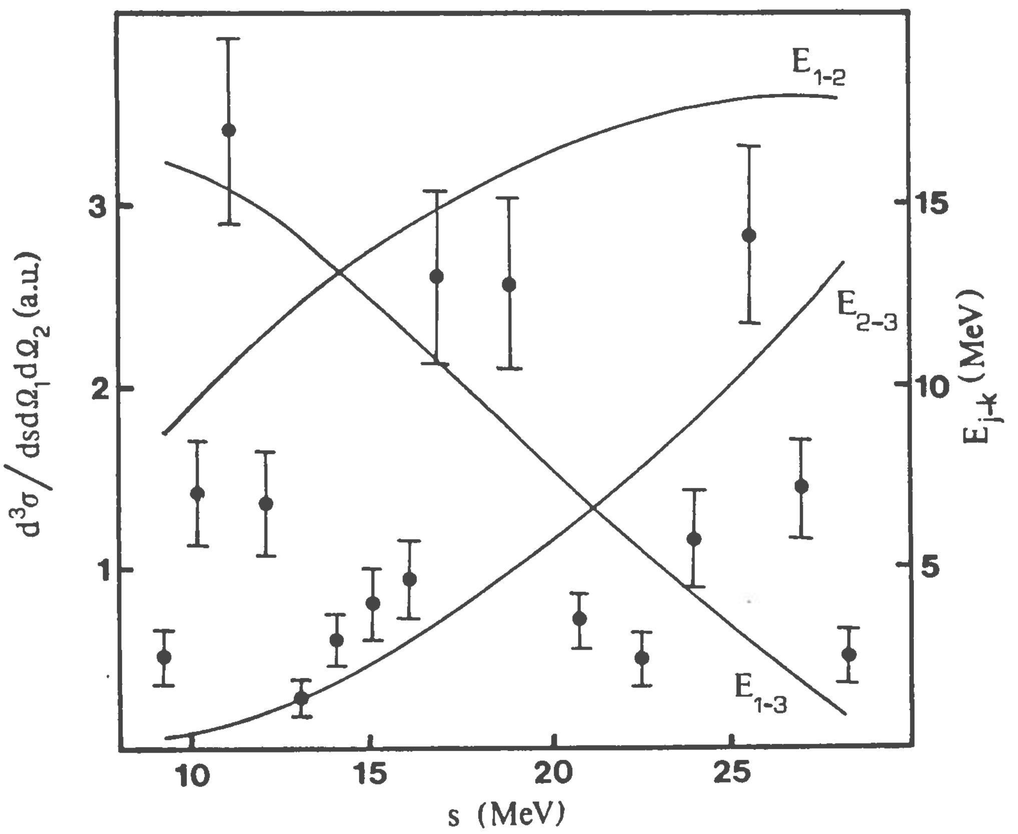

Fig.3.- Distribution of the αd coincidences along the rectified central kinematical curve vs. curvilinear abscissa s for the ϑ_1=80°, φ_1=0° and ϑ_2=40°, φ_2=180° and E(^{3}He) = 11.5 MeV. The curves E_{1-2}, E_{2-3} and E_{1-3} refer to the relative energy of the dα and $\alpha\alpha$ respectively.

In the Laboratory System (LS), by using the appropriate Jacobian, the data were treated with a function of the following type:

$$\Sigma_n C_n(J_{i-jk})^{-1}\varrho_{j-k}$$

Here ϱ_{j-k} is the Lorentzian function for the n-th state, J_{i-jk} the LS→RCS transformation Jacobian for the same state and C_n a constant.
The fit is in good agreement with the experimental data without having to introduce contributions from the break-up even in the spectra where the contributions of the various states are so well separated (as, for example, in the bidimensional spectra at beam energies of 5.0 and 11.5 MeV) that it is correct to sum them incoherently.

This means that in the energy range studied the reaction proceeds with sequentially with the formation of ^{6}Li and ^{8}Be as intermediate nuclei.

The ^{6}Li excitation energy state E_x=5.65 MeV is always present in the spectra and its width values do not appear to depend on the energy of inci-

dent ^{3}He in the range we studied[1,3].
Therefore,we can say,as shown by a bidimensional analysis,that the ^{7}Li(^{3}He,α)^{6}Li(d)α reaction with three bodies (α, α ,d) in the final state, induced by the ^{3}He nuclei with 2.5,5.0 and 11.5 MeV incident energies,can be described by a strong interaction between two particles (α,d) in the final state,while the first emitted α-particle, owing to the relative high energy

$$E_{1-23} = \frac{m_{^7Li}}{m_{^3He} + m_{^7Li}} E(^3He) - E_{2-3} + Q$$

between this one and the complex (α,d), acts as a spectator. The values of E_{1-23} are $\simeq$ 7.95, $\simeq$ 9.70 and $\simeq$ 14.25 MeV for beams of respectively 2.5, 5.0 and 11.5 MeV.
This is,therefore,a sequential decay which can be described as a first direct emission mechanism and a second delayed emission one [4]. Actually the interaction at those energies takes place in two steps:
i) firstly a neutron is quickly transferred ($\tau_1 \simeq 0$) from the ^{7}Li to the ^{3}He(^{3}He+^{7}Li $\rightarrow \alpha +$ ^{6}Li(5.65 MeV));
ii) secondly the ^{6}Li intermediate state decays (^{6}Li(5.65 MeV)$\rightarrow\alpha$+d) in a characteristic time ($\tau_2 \neq 0$) of the strong interaction between α and d particles.
Therefore the $d^3\sigma / dE_{2-3} d\Omega_{1-23} d\Omega_{rel}$ in the RCS, obtained from $d^3\sigma / dsd\Omega_1 d\Omega_2$ using the appropriate LS$\rightarrow$RCS Jacobian,is a function of ϑ_{1-23}, ϑ_{rel} and E_{2-3} and can be factorized as follows:

$$d^3\sigma \,/\, dE_{2-3} d\Omega_{1-23} d\Omega_{rel} = \gamma(\vartheta_{1-23})\, W(\vartheta_{rel})\, \varrho(E_{2-3})$$

where W represents the angular correlation of the $J^\pi = 1^+$, T = 0 at E_x= 5.65 MeV of the ^{6}Li state and γ (characterizing the dependence on the angle) is the angular distribution of the first α-particle emitted at ϑ_{1-23} angle in the relative coordinate system.

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