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THE ^{3}He + ^{6}Li COLLISION AT E_{inc}=5 MeV

P. D'Agostino, G. Fazio, G. Giardina, R. Palamara† and M. Sacchi
INFN, Gruppo Collegato di Messina and Dipartimento di Fisica dell' Universita' Messina

ABSTRACT - The ^{3}He+^{6}Li reaction has been studied in a kinematically complete way at E(^{3}He)=5 MeV by the αp spectra. The deduced value of $\Gamma(^{5}Li_{g.s.})=(1.55\pm0.15)$ MeV is in line with the ones deduced by us using the above ^{3}He+^{6}Li experiment at various incident energies and detector geometries.

Recently some of our works[1-4] have been dedicated to the study of the ^{3}He $+^6$Li$\rightarrow\alpha+\alpha+p$ reaction with the aim of obtaining information on the width of the ^{5}Li ground state. In fact, as one can see by the data present in literature[5], the above spectroscopic parameter appears energy- and angle - dependent.

The previous kinematically complete ^{3}He + ^{6}Li experiments[1-4] were carried out at 1.6, 2.5, 3.5, 7 and 9 MeV ^{3}He incident energies and at various θ_1 and θ_2 detector polar angles. The $\Gamma(^5\mathrm{Li}_{g.s.})$ deduced in all the experiments appear independent from the: *i*) incident energy; *ii*) ^{5}Li$_{g.s.}$ emission angle; *iii*) ^{5}Li$_{g.s.}$ decay proton angle when correlated to the various α-particle emission angles.

In order to complete the ^{3}He + ^{6}Li$\rightarrow\alpha+\alpha+p$ experiment, in this paper we give the results deduced at the E(^{3}He)=5 MeV incident energy by the αp coincidence spectra. The 50 nA ^{3}He beam was produced by the 7 MV CN Van de Graaf machine at the Legnaro National Laboratories. The Li target, obtained by evaporating LiF (99,9% enriched in ^{6}Li) onto a carbon backing of 30μg$\cdot$cm^{-2} thick, was about 120 μg $\cdot$cm^{-2} in ^{6}Li thick.

The experimental apparatus is the one described in Ref. 2. To obtain the αp bidimensional spectra two ΔE-E telescopes were used. The first with a ΔE, totally depleted silicon surface barrier detector, 30 μm thick and an E, silicon surface barrier detector, 100μm thick was used to detect the α-particles; the latter was analogously formed by a ΔE 50 μm and an E 1000 μm and used to detect the protons. The telescope for the α-particles can be rotated in the plane with azimuth ϕ_1=0°; the one for the proton in the plane ϕ_2=180°. In this way the spectral region of our interest was free from $\alpha\alpha$ and $p\alpha$ coincidences. The calibration of the energy pulses of the four detector chains was obtained by the α-particles emitted from a ^{241}Am source (E$_\alpha$=5.48 MeV) put inside the scattering chamber.

During the runs we recorded the two ΔE, the two E energy pulses and the time-of-flight difference (with the time window of about 60 ns) by means of a standard electronic set-up. Later, by selecting an off-line 8ns window, the chance coincidences were reduced to a very low level and no correction to the data was necessary for them. Successively all the events, corrected for the energy shift due to the finite target thickness, were projected onto the $\alpha+\alpha+p$ kinematic loci[6,7].

A ^{3}He beam of 5 MeV on the ^{6}Li target may, through the ^{6}Li(^{3}He, α)^{5}Li(α)p and ^{6}Li(^{3}He, p)^{8}Be(α)α reactions, at our rivelation geometries, in the central part of the kinematic curve, populate the ground and first ^{5}Li states besides the 11.4 MeV ^{8}Be state. Fortunately the low bombarding energy and the 4^+ high spin of the above excited ^{8}Be level do not allow a significant formation of it[8-11]. Now, since in the spectral region of our concern, only the two ^{5}Li states are present, we transformed[1] the αp coincidence distribution by the appropriate Jacobian to the relative coordinate system (RCS). In fact fig. 1, that reported the differential cross section obtained at θ_1=90°, $\phi_1 = 0°$ and θ_2=70°, ϕ_2=180°, show a broad peak due to the above contributions. Here the error bars represent only the statistical errors.

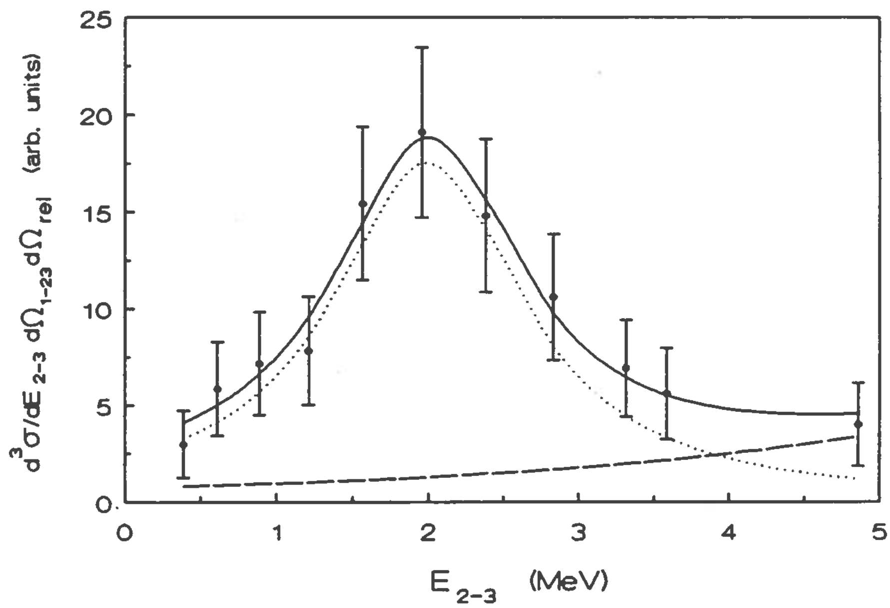

Fig. 1 - Differential cross section versus the relative energy E_{2-3} for the $^3He + {^6Li} \rightarrow 2\alpha + p$ reaction at θ_1=90°, ϕ_1=0°, θ_2=70°, ϕ_2=180° and E(^{3}He)=5 MeV. Dotted line represents the $^5Li_{g.s.}$ contributions. Dashed line represents the first excited ^{5}Li state contributions. Full line is the result of the fit.

In order to separate the two contributions, to obtain the value of the $^5Li_{g.s.}$ width, we used the MINUIT code. By assuming that: *i*) the interference effects among the different contributions can be neglected; *ii*) in the RCS the two above contributions can be represented by a Lorentzian form; *iii*) the characteristic spectroscopic of the first excited ^5Li state[12] and the position of the $^5Li_{g.s.}$[5] are the ones given in literature; the contributions of both ^5Li states are calculated by the code yielding the width of the $^5Li_{g.s.}$ of our concern.

In fig. 1 the contributions as deduced by the fit are reported. The deduced value of the width of the ^5Li ground state is 1.55 MeV with a 150 keV of estimated error obtained by taking into account both the statistical error and the finite energy resolving power of the electronic system.

This value confirms the results previously obtained[1-4] and is in line with the one adopted in literature[5]. Thus we can state that the asymmetry in the shape of the $^5Li_{g.s.}$ energy spectrum, observed by other authors[5], is not an intrinsic property of the spectrum of the above state[1]. In fact the experimental data cannot be reproduced with the single-level R-matrix formalism, when resonance parameters are taken from $\alpha - p$ scattering[1]. On the other hand, a sum of the two ^5Li ground and first excited states (the latter with the low-energy tail) take the experimental data well into account.

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† Present address: Facolta' di Architettura, Universita' di Reggio Calabria

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