Study of breakup phenomena in ^{7}Li + ^{208}Pb reaction

P.K. Rath* and E. Vardaci
for *the FIESTA and EXOTIC collaboration*
Department of Physics, University of Naples "Federico II" and INFN, I-80125 Napoli, Italy
** email:* rath@na.infn.it

Introduction

The study of the reaction dynamics induced by loosely bound projectiles is one of the most challenging topics in nuclear physics, especially in the context of the increasing number of radioactive ion beam facilities [1]. It is well established that besides the scattering one essential process is the fusion of two colliding nuclei at around coulomb barrier energies. In case of stable nuclei, this process is strongly influenced by inelastic excitations of the projectile and/or of the target and/or by possible transfer reactions. Whereas in the case of loosely bound projectiles other degrees of freedom come into play.

There are many studies of the breakup of loosely bound nuclei (^{6}Li & ^{7}Li) have been published where the inclusive α particles cross section was measured [2] assuming the breakup of ^{6}Li in α + d as the main reaction mechanism responsible for the production of α particles, but the trend of the excitation function turns out to be different than in [3]. The transfer breakup (stripping / pickup) is significant compared to direct breakup [4]. The majority of the prompt breakup events are triggered by transfer of a neutron from ^{6}Li and of a proton to ^{7}Li.

It will be interesting to investigate the origin of the inclusive α particles by analyzing the coincidences between α particles and tritium (α – t) within the breakup kinematical cone and the breakup followed by transfer in case of ^{7}Li +^{208}Pb system. Some of the work has been reported in [5], here we presented the transfer breakup (stripping / pickup) process which contributed significantly to the α production.

Experimental detail

The experiment was performed using a ^{7}Li beam delivered by the LNL (Laboratori Nazionali di Legnaro) Tandem Van de Graaff accelerator having beam currents ranged between 5 and 10 nA for beam energy 33 MeV. The target was ^{208}Pb (self-supporting) having thickness 200 μg/cm^{2}. The emitted particles were detected by a 4π array (8πLP) set up [6]. The "WALL" in forward directions (2.5^{0} to 34^{0}) and The BALL in backward (up to 163^{0}) are the two essentially part of the array. The BALL consists of 126 telescopes having a silicon surface barrier detector as ΔE and CsI(TI) scintillator as E (300 μm and 5 mm thick). The 7 rings A, B, C, D, E, F & G covers the angular range from 34^{0} to 163^{0} . The WALL is a matrix of 11×11 telescope. A very good identification of light charged particles: α, t, d and proton was clearly observed. ^{7}Li was completely stopped in the ΔE. The data acquisition has arranged to record for each telescope the ΔE vs Time and E_{res} vs ΔE. matrices to identify each particle independently.

Results and discussions

The detected Particles were identified by the following mechanisms: a) The energy loss (dE/dx) method using ΔE and E_{res} matrix for each telescope b) ΔE Vs Time (T) matrix to separate independent particles including elastic peak. The coincidence between two breakup fragments confirms the different breakup channels. There are different origin for α particles like: the direct breakup of ^{7}Li from its resonance state into α and t; ^{7}Li will pickup of a proton to become ^{8}Be then breaks to (α + α) ; a neutron will strip out from ^{7}Li and becomes ^{6}Li which will break to α and d. Fig.1(a) shows a ΔE vs. Time plot where as Fig.1(b) shows. E_{res} vs ΔE plot for 33 MeV ^{7}Li beam .

From the figure one can observe that there are very nice separations between p, d, t and α has been achived in ΔE vs. E_{res} matrix, whereas the elastic ^{7}Li is visible in ΔE vs. Time matrix. Another observation is that as many particles were stopped in the ΔE so they are not appear in the ΔE vs. E_{res} matrix where as in ΔE vs. Time they are present, this effects the intensity on both the plots but both are from the same telescope.

From the singles and coincidence data differential cross sections have been extracted for different channels and shown in Fig. 2. From the Fig. 2 one can clearly say that the inclusive alpha cross section is much larger than the exclusive (α+t) channel cross section. There are other channels are also in larger significant like ($\alpha+\alpha$) and (α+d) which clearly implies the presence of other reaction channels striping /pickup are important and contribute significantly. The same type of conclusion was also reported in [4,7,8]. The detail analysis to separate out the contribution of different reaction channels will be presented.

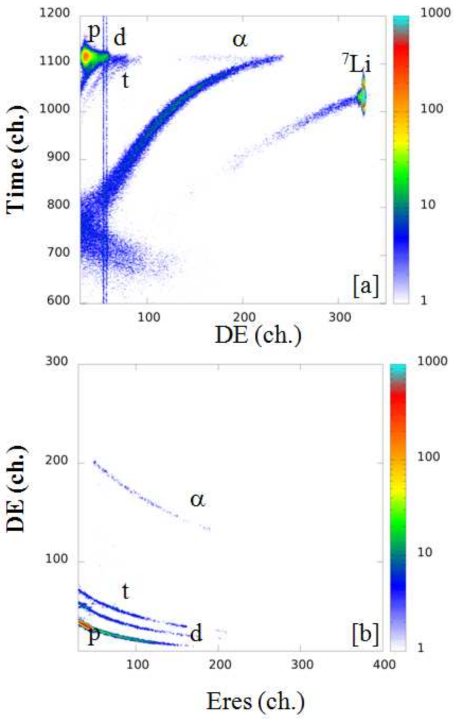

Fig. 1: Experimental two-dimensional particle spectra for ^{7}Li+^{208}Pb reaction at 33 MeV. The telescope was at forward angle (θ=42.97^{0} and ϕ =320.53^{0}). [a] ΔE vs. Time matrix ,where 7Li (elastic) is clearly visible and all other particles are well separated from each other with good statistics. [b] Same telescope but in. Eres vs ΔE matrix. P, d, t, and α are very well separated but with low statistics as some of the particles are stopped in the ΔE.

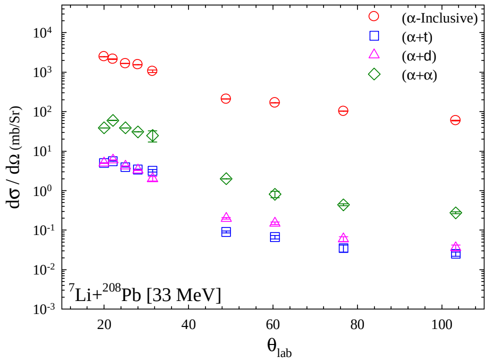

Fig.2: Measured angular distribution for different channels using the singles and coincidence data. (α-inclusive), (α+t), (α+d) and ($\alpha+\alpha$) at E_{lab} 33 MeV for ^{7}Li+^{208}Pb reaction.

Summary

The differential cross-section for different channels for ^{7}Li+^{208}Pb reaction at 33 MeV have been presented. The inclusive α is larger than the exclusive α (α from other channels in coincidence) and also the contribution of $\alpha + \alpha$ are more significant than α +t channels. Which conclude that other reaction mechanisms that provides significant amount of α to the inclusive cross section need further study.

Acknowledgment

One of the authors (P.K.Rath) acknowledges the financial support of University of Naples Federico II, Naples, Italy, in carrying out these investigations.

References

[1] M. K. Pradhan,Phy. Rev. C88,064603 (2013)
[2] G.R. Kelly et al., Phys. Rev. C 63, 024601 (2000).
[3] C. Signorini et al., Eur. Phys. J. A 10, 249 (2001).
[4] D.H. Luong *et al*., Phys. Lett. B **695**, 105. (2011).
[5]P. K. Rath et. al. DAE Symp. 59(2014)608
[6]G. Prete Nucl.Inst.and Meth.A **422** (1999)263
[7] S. Santra *et. al.* Phy. Lett. B 677 (2009) 139
[8]C. Signorini *et al.*, Phy. Rev, C **67**, 044607 (2003)