Measurement of Inclusive and Exclusive breakup for ^{7}Li + ^{208}Pb system

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

Coulomb excitation leading to the continuum (unbound) states in the outgoing channel is a common phenomenon observed in the reactions involving weakly bound nuclei [1]. At energies near threshold, the number of significantly contributing channels becomes relatively small and it is possible to examine in some detail the influences of the various reaction mechanisms arising from differences in the nuclear structure. It is this fact which makes different nuclear processes as a fruitful area of investigation around the barrier energies. Although many studies of the α-breakup of ^{6}Li and ^{7}Li after an interaction with a heavy target have been published, there are only very few reports that compare the breakup of the two isotopes [2]. A report indicates that the effect of transfer breakup is significant compared to direct breakup [3]. As ^{7}Li has larger breakup threshold compared to ^{6}Li, it is interesting to see the origin of α particle from breakup/transfer and their contribution towards the breakup cross sections. The present work describes an experiment, measuring the α-particle (inclusive/exclusive) yield from ^{7}Li+^{208}Pb reaction.

Experimental detail

The experiment was performed using a ^{7}Li beam delivered by the Laboratori Nazionali di Legnaro Tandem Van de Graaff accelerator having beam energy between 31 and 35MeV. Beam currents ranged between 5 and 10 nA. A self-supporting ^{208}Pb target of thickness 200 μg/cm^{2} has been used in the experiment. Light charged particles were detected with a 4π array (8πLP) set up described in detail in [4]. The array is essentially made of two parts: a "WALL" in forward directions, covering the angles from 2.5^{0} to 34^{0} and a "BALL" part covering the angles up to 163^{0} . The ball consists of 126 telescopes. Each telescope consists of a silicon surface barrier detector as ΔE, (300 μm thick), and CsI(TI) scintillator as E (5 mm thick). The angles from 34^{0} to 163^{0} are divided into 7 rings A, B, C, D, E, F & G. The WALL is a matrix of 11×11 telescope (the four at the corners and the central one for the exit hole of the beam missing). This system allows a very good identification of light charged particles: α, t, d and proton. ^{7}Li was completely stopped in the ΔE in our energy range. The data acquisition has arranged to record for each telescope the Time Vs ΔE and ΔE vs. E_{res} matrices for particle identification.

Results and discussions

Particles were identified by two mechanisms: 1) using energy loss information from ΔE and E_{res} for each telescope, 2) ΔE and Time (T). The time is a mix of time of flight and pulse shape discrimination rise time. A good charge and mass resolution was achieved. The breakup channels were identified by making a coincidence between two breakup fragments. The α particles have different origins: as the direct breakup of ^{7}Li from its resonance state at 4.63MeV into α and triton (t); pickup of a neutron (very unlikely) to become ^{8}Be then breaks to (α + α) or strip of a neutron and becomes ^{6}Li which will break to α and deuteron(d). In Fig. 1 a ΔE vs. ER is shown.

From the inclusive and coincidence data differential cross sections have been extracted. The inclusive differential cross section is shown in Fig. 2a for 33 and 35 MeV, whereas the exclusive differential cross section ((α+α)+(α+d)+(α+t)) is shown in Fig.2b.

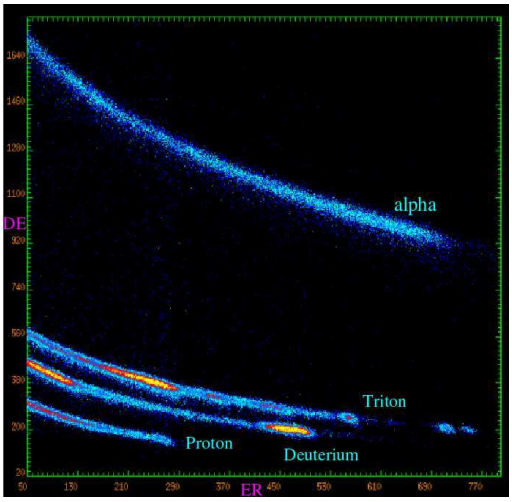

Fig. 1: Experimental two-dimensional particle spectra for ^{7}Li+^{208}Pb reaction at 33 MeV. The telescope was at forward angle (θ =20.6^{0} and ϕ =346.53^{0}. Deuterons and tritons of different energies are clearly separable and are expected to belong to different types of breakup. Different peaks in the triton band indicate different emission process, including breakup via inelastic excitation.

It is clearly shown that the inclusive cross section is much larger than the exclusive cross section. This implies not only that the direct breakup channel is important but that processes besides breakup contribute significantly. The same type of conclusion was also reported in [5]. Quantitatively, about two orders of magnitude are missing. Further investigation to separate out the contribution from other reaction channels will be presented.

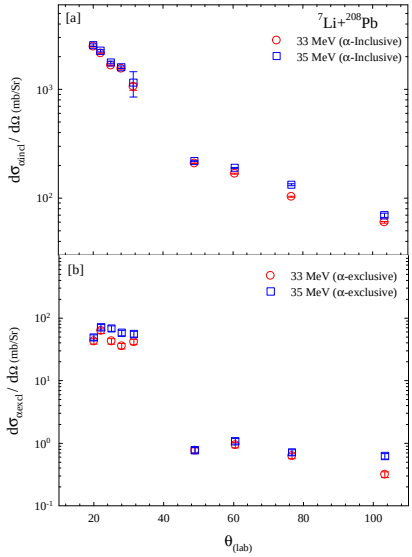

Fig.2: Measured [a] α inclusive [b] α exclusive angular distribution at E_{lab} 33 & 35 MeV for ^{7}Li+^{208}Pb system.

Summary

The inclusive (exclusive) α particle spectra and the differential cross-section of α particle for ^{7}Li+^{208}Pb reaction at 33 and 35 MeV have been presented. The exclusive α particle contribution does not cover the inclusive α cross-sections. We can conclude that other reaction mechanisms which provides significant amount of α to the inclusive cross section need further study.

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