A different approach to study the break-up mechanism using loosely bound nuclei: a case study for ^{7}Li + ^{208}Pb reaction

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Introduction

Reaction mechanism involving weakly bound nuclei is of continue interest due to its wide range of anomalous behavior in experimental observables, an effect due to low breakup threshold [1]. Over the last decade, with the availability of secondary radioactive ion beams, understanding the role of breakup has become a major research focus [2]. Projectile dissociation in the field of target nucleus is a topic of continued interest because of its application to the determination of radiative capture cross section of astrophysical interest. Projectile breakup modifies the accepted picture for two body fusion of strongly bound nuclei. It has been reported that [3] the projectile breakup phenomena can occur either in the vicinity of the target (Direct breakup) or it can break at very far away (elastic, inelastic/sequential breakup). In both the situation the projectile can break in to two or more fragments keeping the heavy recoil nuclei either in ground or excited state. In order to understand the clear picture one has to detect all the exit channels experimentally which is a difficult task. In the measurements involving loosely bound projectiles, the α+x cluster structure show significantly larger cross sections [4] compared to the production of the complementary fragment (x). This indicates that there are mechanisms other than α+x breakup responsible for the above process which needs to be understand [5]. No single theoretical model exist to explain all the above effect simultaneously.

In this report we presented a completely different and simple approach to understand the breakup mechanism using loosely bound nuclei. A 3 body decay mechanism has been simulated using Monte Carlo technique to understand the breakup phenomena. This is a continuation of our previous investigation [6].

Experimental results & Simulation

The experiment was performed at LNL (Laboratori Nazionali di Legnaro) Tandem Van de Graaff accelerator, using a ^{7}Li beam having beam energies 35 and 39 MeV. The beam currents was between 5 and 10 nA. A ^{208}Pb target having thickness 200 μg/cm^2 has been used. The emitted particles were detected by 8πLP set up [7]. The "WALL" & the "BALL" are the two essentially part of the setup which covers forward and backward angles. There are 126 Telescope (ΔE and CsI(TI)) presents in BALL where as the WALL consists of a matrix of 11×11 telescope. The WALL data has been used for the present case. A very good charge and mass identification has been obtained for light charged particles (α, t, d & p). The elastic ^{7}Li was completely stopped in the ΔE. The ΔE vs Time and ΔE vs E_{res} matrices has been reconstructed for each telescope. A variety of particles (α, t, d, p & elastic ^{7}Li) has been detected and very well separated from each other. Presence of all the above particles needs to understand, which has the origin of different reaction process. The breakup events were identified by generating co-relation matrix between the different particles (α & t) using the coincident events which has been shown as insert in Fig. 2.

To understand the above breakup mechanism we have adopted the Dalitz plot method. A Monte Carlo simulation has been carried out by considering the two situations: 1) direct breakup: The projectile will undergo direct breakup in the field of target. 2) Elastics, in elastic/sequential breakup: The projectile undergo scattering and breakup occurs either from any excited stated or from the ground state of the ejectile. This process occurs at very far away from the target by keeping the recoil/Residue in either ground or in excited state. The main key point of the Dalitz plot is the total energy and momentum conservation.

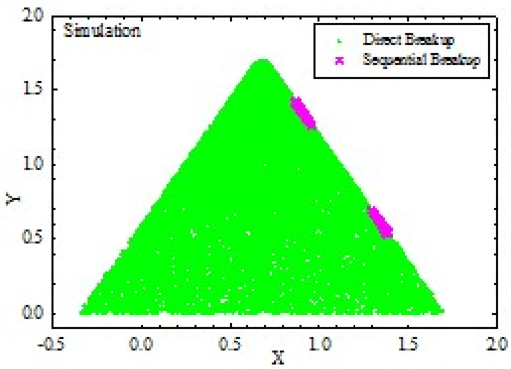

Fig. 1 Monte Carlo simulation of the Direct and the sequential breakup for 35MeV of Projectile energy. The breakup has been considered from the ground state of the projectile. The events has been filtered through the geometry of 8πLP.

Dalitz plot provides an excellent tool for studying the dynamics of three-body reaction. The energies and linear momenta of the decay particles for each event in the rest frame of the decaying nucleus have been generated in such way that the total energy (E_{total}) of the three particles is equal to E_{tot}= E1+E2+E3. The three particles will be represented by an equilateral triangle having each sided are the possible energies of each one. Any points within the triangle is such that the perpendicular distances to its three sides are equal in corresponding two-particle decay from the intermediate state. Any point within the triangle can be expressed in (X,Y) coordinates [8]. For the case of direct breakup, none of the energies are constrained and the data points will be distributed uniformly over the triangle, where as in case of sequential decay it will impose a constrain on the kinetic energies of the particles and for a definite total energy in center of mass frame, the three particle (α, t , Recoil) have a continuous distribution of energy within an energy window which will be restricted by the kinematics. For the present case the complete experimental geometry of the setup has been simulated and the coincidence event has been reconstructed. The transformation of the coincidence breakup event (α & t) has been done and shown in Fig.1 for both direct and sequential breakup.

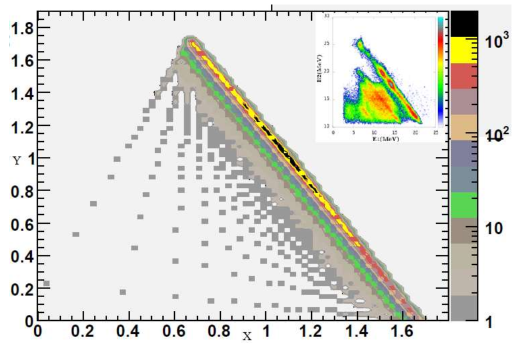

Fig. 2. The Dalitz triangle representation of the coincidence breakup events at E_{lab}= 35 MeV. The insert shows experimental coincidence data (E_{α}-E_{t}).

From Fig.1 one can observe that the sequential breakup events are completely restricted within a section of the triangle whereas the direct breakup has been shown as continuous random distribution within the triangle. The details of the calculation and event reconstruction will be presented. The transformation of the experimental data to Dalitz triangle has been shown in Fig.2. The analysis is on progress and the results will be discussed.

References

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