1 Introduction

Exotic nuclei are systems rich in neutrons or protons. They are unstable nuclei with short half-life. Due to the fact that they are far away from the stability valley, the way they interact with other nuclei and their structure can be very different from that of stable nuclei. In this work, we study the $^{6}$Li reactions with $^{208}$Pb at laboratory energies around the Coulomb barrier at TRIUMF facility (Canada).

2 Experimental Setup

The experiment was performed at the ISAC-II line of the radioactive beams facility of TRIUMF (Canada). The detection system consisted of 4 silicon telescopes ($\Delta$E-E) covering a wide angular range, from 10$^\circ$ to 140$^\circ$. This set-up allowed us to separate $\Delta$E fragments coming from the breakup of the $^{6}$Li projectile.

3 $\Delta$E vs E Diagrams

Figure 3 shows two-dimensional diagrams ($\Delta$E vs E) of the total events acquired through detectors 1 at two different incident energies (24.3 and 29.8 MeV), integrated for the pixels corresponding to the angular bins of (3(1.5)$^\circ$).

4 Experimental data

Figure 4 (left) shows the elastic scattering angular distribution of the $^{6}$Li+$^{208}$Pb reaction [2] and the corresponding 3b-CDCC calculations at 24.3 and 29.8 MeV. 3b-CDCC calculations are based on a simple two-body model of $^{6}$Li ($^{2}$n). An impressive suppression of the $^{6}$Li elastic cross section with respect to the Rutherford prediction is observed.

4 Experimental data

In figure 4 (right) we present the experimental data of the $^{6}$Li breakup probability (ratio between $^{6}$Li events resulting from the two-neutron removal process in the $^{6}$Li+$^{208}$Pb reaction [3]). We compare the experimental data with semiclassical and CDCC calculations. The semiclassical calculations include only the first order Coulomb excitation (E1) and the breakup probability is given by equation (1). The CDCC calculations include both Coulomb and nuclear couplings to all orders.

$$P_{\text{E1}}(E1, t) = \frac{2\pi e^{2}}{5\hbar c} \frac{9}{\sqrt{9}} \int \frac{dE}{c^{4}} \left[ I_{1} + I_{2} \right]$$

5 Reduced Breakup Probability

It is useful to define the reduced breakup probability given by equation:

$$P_{t}(t) = P_{\text{E1}}(E1, t) \sqrt{B(E1)}\frac{\hbar}{16\pi} (\frac{e}{c})^{2}$$

where $t$ is the collision time: $t = \frac{\hbar}{m_{\text{nucl}} c} \sqrt{\frac{E_{\text{lab}}}{m_{\text{nucl}}}}$. When dipole Coulomb excitation is dominant, the reduced breakup probability becomes an universal function of the collision time, independent of the collision energy.

$$P_{t}(t) = \int_{0}^{\infty} c^{2} dE \frac{(1 + e^{-2t})}{c^{2}} e^{c^{2}}$$

where, for large collision times, the $B(E1)$ distribution is approximated by $c^{2} \sqrt{B(E1)} \simeq 2.5 m_{\text{nucl}} c^{2}$.

5 Reduced Breakup Probability

In figure 6 we can see that the reduced breakup probability, for collision times larger than 5 MeV$^{-1}$, is indeed independent on the collision energy.

6 Summary and Conclusions

- We have presented the experimental setup used to measure the breakup of $^{6}$Li on $^{208}$Pb at energies around the Coulomb barrier at TRIUMF facility (Canada).
- The set-up allowed us to separate elastically scattered $^{6}$Li from $^{6}$Li breakup fragments in $^{6}$Li+$^{208}$Pb reaction.
- A strong reduction of the $\sigma_{\Delta E}$ with respect to $\sigma_{\text{inel}}$ have been observed.
- We have defined a new magnitude referred to as reduced breakup probability. This magnitude is a function of the collision time and is independent of the collision parameters.
- From the experimental reduced breakup probability, we can obtain a value of the effective breakup energy of $\sim 0.35(4)$ MeV and the parameter $b_{0}$ which is associated with the slope of the $B(E1)$ distribution.
- The experimental data suggest more strength of the $B(E1)$ distribution than the distribution obtained by Nakamura [4].

References