Breakup reactions from ^{7}Be + ^{12}C at 5 MeV/u

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Abstract. The measurement of the breakup of the radioactive nucleus ^{7}Be on ^{12}C at 5 MeV/u is reported for the first time. Significant coincidence counts of α and ^{3}He from ^{7}Be breakup have been identified. Analysis is ongoing to identify the breakup events from a direct or sequential process.

1 Introduction

Breakup reactions involving loosely bound stable and unstable nuclei are very important in the field of nuclear physics and nuclear astrophysics. Extensive measurements of the breakup of ^{7}Li have been carried out earlier [1, 2]. The breakup threshold of ^{7}Li is 2.467 MeV and both direct and sequential breakup through the 4.63 MeV state have been measured using several targets ranging from ^{12}C to ^{208}Pb [3]. Though breakup studies with ^{7}Li have received substantial attention, very few works exist that involve its mirror counterpart ^{7}Be. The ^{7}Be nucleus has a prominent α + ^{3}He cluster structure with a lower breakup threshold of 1.587 MeV. Mazzocco *et al.*, [4, 5] carried out experiments involving ^{7}Be on ^{58}Ni and ^{208}Pb targets at energies around the Coulomb barrier leading to very low exclusive breakup events. Also, no significant coincidence counts were observed for ^{7}Be + ^{12}C studies carried out by Amro *et al.*[6]. Direct and sequential breakup through the 4.57 MeV and 6.73 MeV resonant states of ^{7}Be have been carried out via the transfer reaction ^{112}Sn(^{6}Li,^{7}Be)[7]. However, breakup data of ^{7}Be on ^{12}C are not available. A detailed study of breakup of ^{7}Be in comparison to ^{7}Li may shed light on the relative importance of direct and sequential breakup.

2 Experiment

The experiment was carried out at HIE-ISOLDE, CERN with a 5 MeV/u ^{7}Be beam of intensity $\sim 10^{5}$ pps. A CD_2 target of thickness 15 μm was used. The charged particle detector setup consisted of 5 double sided 16 ×16 silicon strip detectors (W1) in a pentagon geometry

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covering 40°- 80° in the lab. These were backed by unsegmented silicon-pad detectors in $\Delta E - E$ telescope configuration. The forward angles ~ 8° - 25° were covered by an annular detector (S3). The back angles ~ 120°- 165° were covered by two DSSDs (BB7) backed by unsegmented silicon-pad detectors. The details of the experimental setup are given in Ref.[8, 9].

3 Results

The Monte Carlo simulations for the breakup of ^{7}Be on ^{12}C were carried out by NPTool [10]. The experimental $\Delta E - E$ spectrum (Fig. 2 of Ref. [8]) shows clear bands of ^{3}He and α. Since ^{3}He and α may also come from transfer reactions, suitable gates and conditions were applied to identify the events only from breakup. Exclusive energy spectra of breakup fragments were obtained from the coincidence detection of ^{3}He and α with multiplicity of two in the pentagon detectors. The energy correlation spectrum of coincident ^{3}He and α (Fig. 1) shows significant breakup counts from ^{7}Be + ^{12}C reaction. The inset in Fig. 1 represents the coincident energy spectrum for (a) ^{3}He and (b) α from ^{7}Be breakup. The breakup reaction may occur as a direct

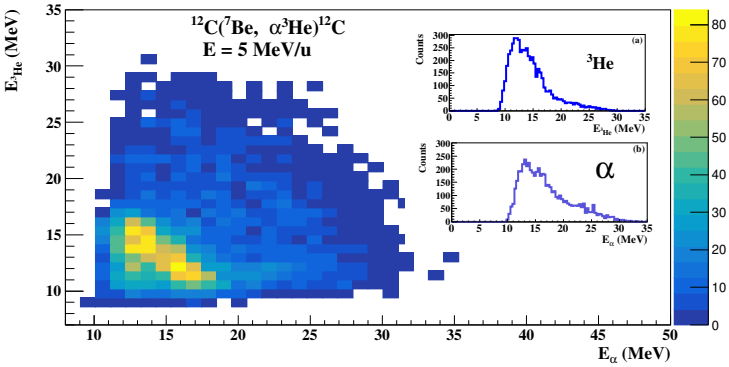


Figure 1: Energy correlations of coincident ^{3}He and α from the breakup of ^{7}Be on ^{12}C at 5 MeV/u. The inset shows the coincident energy spectrum for (a) ^{3}He and (b) α.

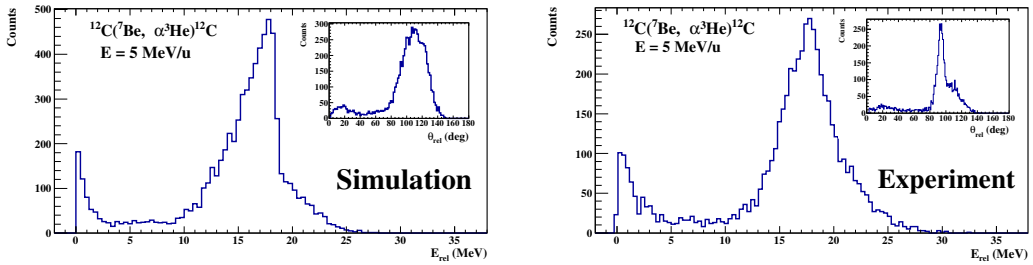
breakup, or a sequential breakup through resonance states in the continuum of the nucleus. The relative energy distribution between the breakup fragments helps to identify the breakup events. The expression for the relative energy (E_{rel}) is given by eqn. 1, where θ_{rel} is the opening angle of the breakup fragments in eqn. 2. The θ and ϕ are the polar and azimuthal angles of the two breakup fragments.

$$E_{rel} = \frac{m_1 E_2 + m_2 E_1 - 2\sqrt{m_1 m_2 E_1 E_2}\cos\theta_{rel}}{m_1 + m_2} \tag{1}$$

$$\cos\theta_{rel} = \cos\theta_1 \cos\theta_2 + \sin\theta_1 \sin\theta_2 \cos(\phi_1 - \phi_2) \tag{2}$$

Fig. 2 represents the relative energy distribution and opening angle of the coincident ^{3}He and α-particles from ^{7}Be breakup. The preliminary results from Monte Carlo simulations of direct breakup and the experimental data are shown in Fig. 2a and Fig. 2b respectively. In the E_{rel} distribution of the experimental data (Fig. 2b), a peak at ~ 0 MeV can be seen, which corresponds to events from direct breakup of ^{7}Be. Further work in this regard is in progress, namely the α - ^{3}He coincidence detection efficiency of the detector setup as a function of

E_{rel}. This efficiency correction can be obtained from Monte Carlo simulations and needs to be incorporated into the relative energy distribution to clearly identify the contribution of direct and sequential breakup of ^{7}Be.



(a) (b)

Figure 2: The relative energy distribution (preliminary) of coincident ^{3}He and α from the breakup of ^{7}Be on ^{12}C at 5 MeV/u. The results from (a) Monte Carlo simulations of direct breakup and (b) experimental data are shown. The insets in (a) and (b) show the opening angle distribution of the breakup fragments.

4 Conclusion

The present work reports the first exclusive measurement of the breakup of ^{7}Be on ^{12}C at 5 MeV/u over a wide angular range. The study is important in the context of previous work by Amro *et al.* [6], concluding that transfer reaction is more prominent than breakup of ^{7}Be. The contribution of direct and sequential breakup of ^{7}Be would also be studied and compared to that of the mirror nucleus ^{7}Li.

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