Breakup of ^{7}Be from ^{7}Be + d reaction at 5 MeV/u

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Introduction

Studies involving light radioactive nuclei have opened up several avenues in nuclear physics and nuclear astrophysics [1–3]. Breakup reactions of loosely bound stable and unstable nuclei having prominent cluster structures are particularly interesting [4–7]. The radioactive nucleus ^{7}Be has been studied in the context of breakup, stripping, transfer and capture reactions [2, 3, 7–9]. In the present work, we look into the projectile breakup of ^{7}Be on deuteron target at 5 MeV/u. Both ^{7}Be and deuteron are loosely bound with binding energies of 1.586 and 2.225 MeV respectively. Earlier, studies involving ^{7}Be breakup were carried out with higher mass tagrets [7–9]. In this context, ^{7}Li breakup on proton target at 5.44 MeV/u shows low breakup cross sections of ^{7}Li from its 4.63 MeV ($7/2^-$) resonance state [5]. Our study would give insight to the relative importance of breakup contributions of ^{7}Li with respect to its mirror nucleus ^{7}Be for interactions with light targets. The ^{7}Be(d,p)^{8}Be* transfer reaction has been studied in our earlier work [2]. Another study of reaction involving breakup of deuteron with ^{7}Be is also in progress [10]. The present work would study the relative importance of breakup and transfer reactions in ^{7}Be + d reaction at 5 MeV/u.

Experimental Results

The experiment was carried out at HIE-ISOLDE CERN with a 5 MeV/u ^{7}Be beam on a 15 μm CD_2 target. The detectors are a 1000 μm annular strip detector S3 covering $8^\circ - 25^\circ$ in lab and five DSSDs of thickness 60 μm W1 backed by unsegmented silicon-pad detectors of thickness 1500 μm in ΔE-E configuration covering $40^\circ - 80^\circ$ in lab. The details of the experimental setup is given in Ref. [2, 3]. Extensive Monte Carlo simulations were also carried out using NPTool [11]. Since ^{7}Be is incident on a light mass target d, breakup fragments fall in S3. There is no particle identification in S3. Thus, Monte-Carlo simulations, $E - \theta$ plots of particles detected in S3 were used to identify breakup fragments and recoil nuclei. Triple coincidences were used for identification

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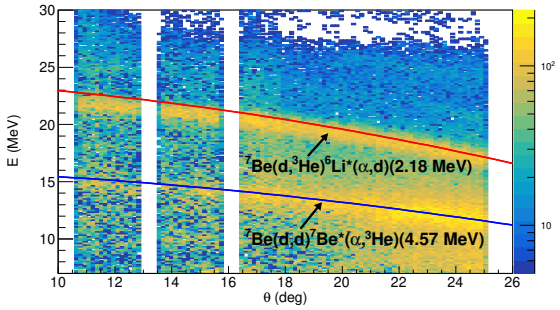

FIG. 1: E vs θ plot in S3. Upper band corresponds to ^{7}Be(d,^{3}He)^{6}Li*(α,d) for 2.18 MeV (3^+) state and lower band corresponds to ^{7}Be(d,d)^{7}Be*(α,^{3}He) for 4.57 MeV ($7/2^-$) state.

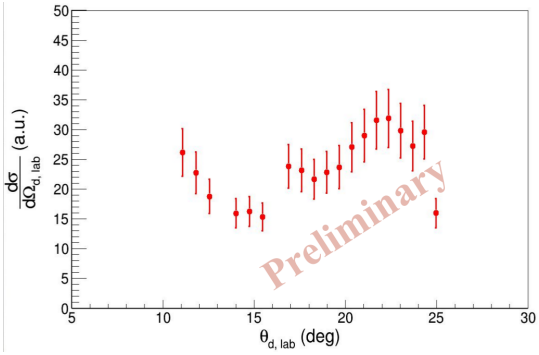

FIG. 2: Angular distribution of ^{7}Be(d,d)^{7}Be*(α,^{3}He) for 4.57 MeV ($7/2^-$) excited state of ^{7}Be at 5 MeV/u.

of ^{7}Be breakup events.

Discussion

Fig. 1 shows the energy vs θ plot obtained from S3 detector by applying triple coincidence and energy gates. A prominent deuteron band corresponding to sequential breakup of ^{7}Be from 4.57 MeV ($7/2^-$) state is seen. This may be compared to the ^{7}Li breakup from 4.63 MeV ($7/2^-$) state [5]. The upper band corresponds to ^{7}Be(d,^{3}He)^{6}Li* reaction corresponding to 2.18 MeV (3^+) state, which subsequently breaks up into α and d. Fig. 2 shows the preliminary angular distribution of ^{7}Be breakup into α and ^{3}He in lab frame. Detailed studies are in progress.

Acknowledgments

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References

[1] C. A. Bartulani, Phys. Rep. 485, 6 (2010).
[2] Sk M. Ali et al., Phys. Rev. Lett. 128, 252701 (2022).
[3] K. Kundalia et al., Phys. Lett. B 833, 137294 (2022).
[4] D. Gupta et al., Nucl. Phys. A 646, 2 (1999).
[5] A. Pakou et al., Phys. Rev. C 95, 044615 (2017).
[6] D. Chattopadhyay et al. Phys. Rev. C 97, 051601(R) (2018).
[7] N. C. Summers et al. Phys. Rev. C 70, 011602(R) (2004).
[8] O. Sgouros et al. Phys. Rev. C 94, 044623 (2016).
[9] M. Mazzocco et al. Phys. Rev. C 92, 024615 (2015).
[10] S. Maity et al., DAE Symp. on Nucl. Phys. 66 (2022).
[11] A. Matta et al., J. Phys. G: Nucl. Part. Phys. 43, 045113 (2016). https://github.com/adrien-matta/nptool