Role of clustering in decay of ^{24,25}Mg*

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Introduction

The role of clustering (more specifically α clustering) in the fragment emission mechanism of light composite systems ($A_{CN} \lesssim 60$) has been a topic of contemporary research in recent times, both in theoretical and experimental fields. In the past few years extensive research effort have been devoted in the experimental front to study the fragment emission mechanism in the reactions involving α cluster nuclei [1, 2]. The outcome of these experiments was the observation of the enhancement in yield in a few outgoing channels near the entrance channel indicating the influence of orbiting type of phenomena. At this point it is interesting to see if the clustering phenomena manifests itself in the compound nuclear type of decay into exit channels away from the entrance channel. We report here the results of fragment emission studies on ^{12}C + ^{12}C and ^{13}C + ^{12}C reactions. We have found the signature of α clustering on the fragment emission from fully energy relaxed composites ^{24,25}Mg* at an excitation energy ∼54 MeV.

Experimental Details

The experiment has been carried out at BARC-TIFR Linac facility using 80 MeV ^{12}C and 78.5 MeV ^{13}C ion beams on ^{12}C target. The details of the experiment can be found in Refs.[3, 4].

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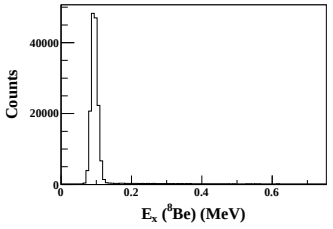

FIG. 1: The relative energy spectrum of 2 coincident α's (see text).

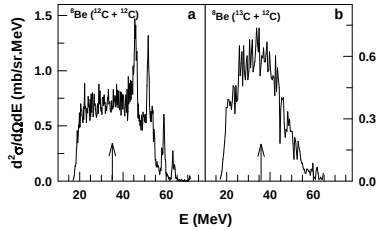

FIG. 2: (a)The g.s. energy distribution of ^{8}Be in ^{12}C + ^{12}C reaction (b) Same for the ^{13}C + ^{12}C reaction. Arrow shows the mean energy of the fragment obtained from Viola systematics (see text).

Results and discussion

The energy distributions of different isotopes of Li and Be fragments obtained in the ^{12,13}C + ^{12}C reactions are found to be nearly Gaussian in shape, having their centroid near the expected kinetic energies for the fission fragments as predicted by the Viola systematics (with correction by corresponding asymmetry factors) [5]. This has been discussed and shown in Refs. [3, 4] except for ^{8}Be

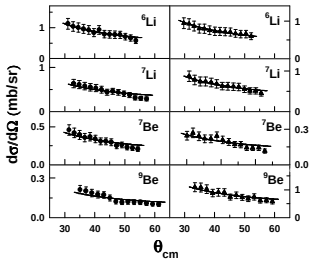

FIG. 3: The center of mass (cm) angular distribution of Li and Be isotopes for ^{12}C + ^{12}C (solid circles) and ^{13}C + ^{12}C (solid triangles) reactions. The solid lines correspond to dσ/d$\Omega \sim 1/\sin\theta_{cm}$ fit to the data.

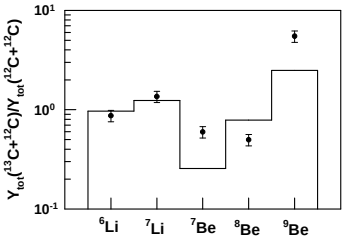

FIG. 4: Ratio of fragment yields in ^{13,12}C + ^{12}C reactions. Solid circles represent the data and the histogram shows the corresponding statistical model prediction.

which is unstable and decays into 2α instantaneously. The relative energy of the two coincident α's has been calculated for all detected events, which was found to peak at ∼92 keV, as expected for the decay of the g.s. of ^{8}Be (Fig.1). The ground state energy spectrum of ^{8}Be was then reconstructed from these events assuming binary break-up of the composite as shown in Fig.2(a) and Fig.2(b) for the reactions ^{12}C + ^{12}C and ^{13}C + ^{12}C respectively. These spectra are also nearly Gaussian in shape, and peak positions follow Viola systematics (shown by arrows) as described earlier. This indicates that, in all cases, the fragments are emitted from a fully energy relaxed composite as expected for statistical decay of a compound nucleus. The angular distributions of the fragments in centre of mass, have been deduced as described in Ref.[1] and are shown in Fig. 3. All are found to follow ∼ $1/\sin\theta_{cm}$ dependence (shown by solid lines in Fig. 3) which further confirms that these fragments have been emitted from a fully energy equilibrated system. The ratios $[R^{exp(Th)} = (Y_{tot}(^{13}C +^{12} C)/Y_{tot}(^{12}C +^{12} C))^{exp(Th)}]$ of yields of each fragment in the two reactions have been compared with the statistical model (CASCADE) [6] prediction for the same as shown in the Fig. 4. It is found that the prediction of CASCADE matches well for the ^{6,7}Li fragments, but deviates significantly for the fragments ^{7,8,9}Be. This deviation is indicative of the effect of cluster correlation in fragment emission mechanism which will be discussed in this symposium.

Conclusion

The fragment emission mechanism have been studied in ^{13,12}C + ^{12}C reactions. The relative yields of the isotopes of Li and Be emitted from fully energy relaxed composites ^{24,25}Mg* were compared with the corresponding statistical model predictions. The theoretical yield ratios agreed well with experimental results for ^{6,7}Li, but deviated significantly for ^{7,8,9}B, which indicated the survival of α clustering in the exit channel of the compound nucleus decay at excitation energy ∼54 MeV.

References

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