Fragment emission studies in $^{12}C+^{12}C$ reaction

*S. Kundu[1], C. Bhattacharya[1], T. K. Rana[1], K. Banerjee[1], T. K. Ghosh[1], G. Mukherjee[1], A. Dey[1], S. Bhattacharya[1], J. K. Meena[1], S. Mukhopadyay[1], D. Gupta[2], Suresh Kumar[3], S. K. Pandit[3], S. Santra[3], K. Mahata[3], A. Chatterjee[3], K. Ramachandran[3]
[1]*Variable Energy Cyclotron Centre, 1/AF, Bidhan Nagar, Kolkata - 700 064, INDIA*
[2]*Dept. of Physics and Centre for Astroparticle Physics & Space Science, Bose Institute,Kolkata 91, INDIA*
[3]*Nuclear Physics Division, Bhabha Atomic Research Centre, Trombay, Mumbai - 400085, INDIA*
* *email: skundu@vecc.gov.in*

Extensive works [1] have been done to investigate fragment emission mechanism in light-heavy ion reaction at low energy. Inelastic transfer, projectile breakup, fusion-evaporation, fusion fission, deep-inelastic process etc. are the main reactions by which fragments are emitted in this type of reactions. Though in most of cases, fragment emission is explained by the above reaction mechanisms, some exceptions there are in reactions involving with α-clustered nuclei, e.g, $^{20}Ne + ^{12}C$, $^{24}Mg + ^{12}C$, $^{28}Si + ^{12}C$ etc. For these systems, enhancement in the yield and/or resonance-like excitation function in a few outgoing channels (near to the entrance channel) have indicated the role played by deep inelastic orbiting process in fragment emission. Here we report our measurement of fragment emission in ^{12}C (77 MeV) on ^{12}C reaction.

The experiment was carried out at BARC-TIFR 14UD Pelletron, Mumbai, using 77 MeV ^{12}C ion beam. The target used was self-supporting ^{12}C with thickness ~568 $\mu g/cm^2$. Emitted fragments have been detected in Si(SB) telescopes (~10 μm ΔE, ~5 mm E). Typical solid angle covered by the detector was ~ 0.22 msr. The calibration of telescopes were done using elastically scattered ^{12}C ion from ^{197}Au target. Inclusive energy distributions for the various fragments ($3 \leq Z \leq 5$) were measured in the angular range of 7^0 to 35^0. (which covered the angular range 18^0–90^0 in the center-of-mass (c.m.) frame). The systematic errors in the data have been estimated to be ≈15%. These include the errors arising from the uncertainties in the measurements of target thickness, solid angle and the calibration of current digitizer.

The inclusive energy distribution of the fragments Li, Be and B obtained in $^{12}C + ^{12}C$ reaction, is shown in Fig. 1. The energy damped yield of the fragments have been extracted by fitting the energy distributions with a Gaussian (shown by solid lines in Fig. 1) having its centroids at the energies obtained from Viola systematic. The details can be found in ref [2, 3].

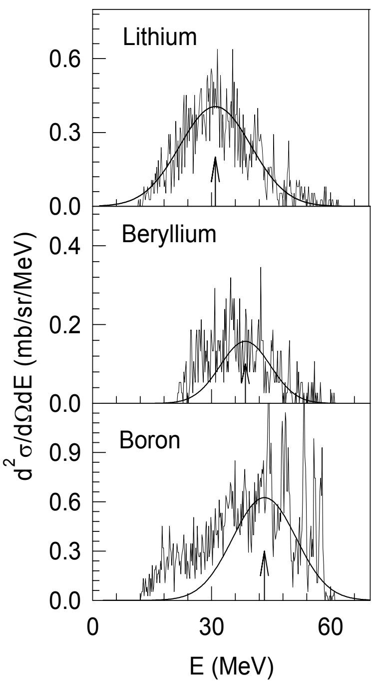

Fig.1 Typical energy spectra of emitted fragments (Li, Be and B) detected at an angle θ_{lab} = 12.5^0. Arrows indicate the centroid of the Gaussian distributions.

The width of the Gaussian was obtained by fitting the higher energy tail of the respective energy spectra, assuming it to be originating purely from the FF process [2].

The differential cross-sections for energy damped yield of the fragments Li, Be and B were obtained by integrating the respective energy distributions under the fitted Gaussian. The centre of mass (c.m.) angular distributions $(d\sigma/d\Omega)_{c.m}$ of the fragments Li, Be and B obtained in the reaction ^{12}C + ^{12}C are shown in Fig. 2, by filled circles, solid triangles and inverted triangles respectively. The angular distribution of Li, Be and B fragments are found to follow $1/\sin\theta_{c.m}$ dependence in c.m. frame (shown by solid lines in Fig. 2), which is a characteristics of fission like decay of compound nucleus.

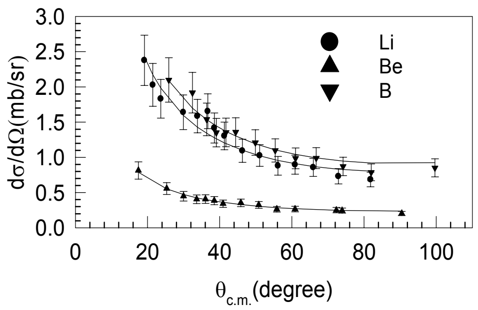

Fig. 2 The c.m. angular distributions of the Fragments Li, Be and B fragments. Solid circle/triangles correspond to experimental data and solid lines are $f(\theta_{c.m.})\ \alpha\ 1/\sin\theta_{c.m}$ fit to the data.

The angular variation of the average <Q> value of the fragments, provides information on the degree of equilibration. The variation of <Q>, with c.m. angle for the fragments Li, Be and B obtained are shown in Fig. 3. It is observed that <Q> values for all the fragments are independent of center of mass emission angles which further suggests that the fragments are emitted from a completely equilibrated source.

All these observations indicate that the extracted binary reaction yield of these fragments originate from the decay of a long-lived fully energy relaxed source, which may either be a CN or a long-lived orbiting dinuclear system. The yield of the fragments Li, Be and B, obtained by integrating the fitted angular

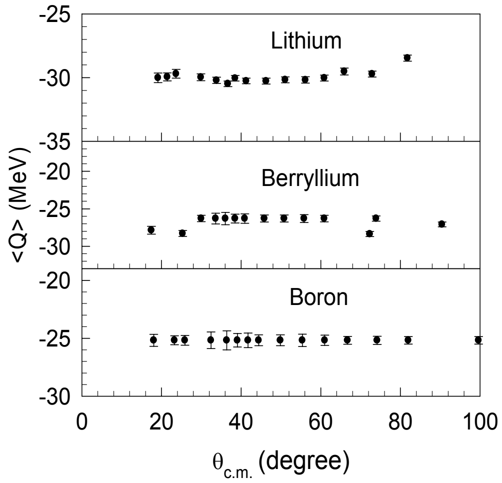

Fig. 3 Average <Q> values of the fragments Li, Be, and B plotted as a function of c.m. emission angle $\theta_{c.m.}$

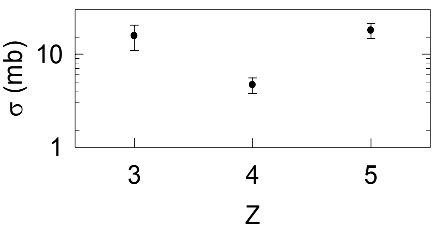

Fig. 4 Angle-integrated (over the range $0^0 \le \theta_{c.m} \le 180^0$) cross section of the Li, Be, and B fragments.

distribution over the range $0^0 \le \theta_{c.m} \le 180^0$, are shown in Fig. 4. A detailed investigation is being done to decipher the role played by aforementioned processes in the fragment emission by comparing the extracted binary-reaction yields with the theoretical predictions.

References

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