Dissipative collision studies in ^{11}B + ^{28}Si, ^{12}C + ^{27}Al, ^{12}C + ^{28}Si

S. Kundu[1*], C. Bhattacharya[1], T. K. Rana[1], K. Banerjee[1], A. Dey[1], T. K. Ghosh[1],
G. Mukherjee[1], S. Bhattacharya[1], J. K. Meena[1], S. R. Banerjee[1], S. Mukhopadhyay[1,]
D. Pandit[1], P.Mali[2], D. Gupta[3], A. Shrivastava[4], Suresh Kumar[4], A. Chatterjee[4],
K. Ramachandran[4] , P. Banerjee[5]
[1]Variable Energy Cyclotron Centre, 1/AF, Bidhan Nagar, Kolkata - 700 064, INDIA
[2]Dept. of Physics, University of North Bengal, Silliguri - 734013, INDIA
[3]Dept. of Physics and Centre for Astroparticle Physics and Space Science
Bose Institute, Block EN, Sector V, Salt Lake City, Kolkata 700091, INDIA
[4]Nuclear Physics Division, Bhabha Atomic Research Centre, Trombay, Mumbai - 400085, INDIA,
[5]Presidency University, Kolkata-700073, INDIA
** email:skundu@veccal.ernet.in*

Orbiting is found to play an important role in fragment emission for the reactions involving α-cluster nuclei (e.g., ^{20}Ne + ^{12}C, ^{24}Mg +^{12}C, ^{28}Si +^{12}C)[1-3]. It has been observed that the energy damped yield of the fragments emitted in the reactions ^{28}Si + ^{12}C at energies 29.5<$E_{c.m}$ <50MeV are well described by orbiting process [3]. Recently, we have studied fragment emission from the compound system ^{39}K* produced at excitation energy (67 MeV) via two different reactions viz. ^{11}B (64 MeV) + ^{28}Si and ^{12}C (73 MeV) + ^{27}Al with the aim to see how the fragment emission mechanism changes as one moves to nearest non-alpha cluster system viz. ^{39}K*. The results were compared with those obtained from an α-cluster system (^{40}Ca*) produced via. the reaction ^{12}C (77 MeV) + ^{28}Si, for which orbiting phenomenon has already been established in inverse kinematical reaction viz. ^{28}Si (180 MeV)+ ^{12}C [3]. A significant difference have been observed in the energy damped yield of the fragments (3≤ Z≤5) emitted from α-cluster system (^{40}Ca*) and non alpha cluster nuclei ^{39}K*[4]. Absence of any entrance channel dependence of energy damped yield of the fragments(3≤Z≤5), conjectured that these emission is of compound nucleus origin[4]. Apart from the damped yield, the energy distribution of each fragment show a second component which is due to deep inelastic part. Here, we report the dissipative collision studies for these reactions.

The experiments have been performed at BARC-TIFR 14UDPelletron, Mumbai, using 77, 73 MeV ^{12}C and 64 MeV ^{11}B ion beams on ^{27}Al and ^{28}Si targets . Emitted fragments (3 ≤ Z ≤ 5) have been detected in Si-Si and Gas-Si telescopes in a wide angular range [4].

Inclusive energy distributions for the fragments Li, Be and B emitted in the reactions ^{11}B (64 MeV) + ^{28}Si, ^{12}C (73 MeV) + ^{27}Al and ^{12}C (77 MeV) + ^{28}Si, respectively, are displayed in Fig. 1. The energy distributions have been fitted with two Gaussian (shown by dotted lines and dashed lines in Fig. 1), one having centroids at the energies obtained from Viola systematic (shown by left arrows), which gives the energy damped part, and another component with a centroid at higher energies, corresponds to deep-inelastic part shown by right arrows.

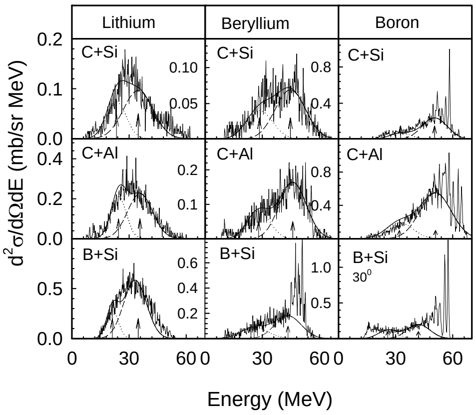

Fig. 1 Typical Energy spectra of the fragments Li and Be, B at different angles emitted in the above reactions.

The differential cross-sections for DI component of each fragments were obtained by integrating the respective part of the energy distributions under the fitted Gaussian. The c.m. angular distributions so obtained for the fragments ($3 \leq Z \leq 5$) are displayed in Fig. 2, as a function of c.m. angle $\theta_{c.m}$. A rapid fall of the angular distribution than predicted by $1/\sin\theta_{c.m}$ distribution indicates a shorter life time of the composite system. From the measured forward peaked angular distribution it is possible to estimate the life time of the intermediate di-nuclear complex using a diffractive Regge -pole model [5].

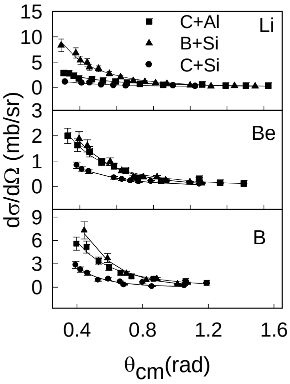

Fig. 2. The c.m. angular distributions of the DI components of the fragments Li, Be and B obtained in the three different reaction.

The angular distributions are fitted with the following expression:

$$\frac{d\sigma}{d\Omega} = \frac{C}{\sin\theta_{c.m}} e^{-\theta_{c.m}/\omega t}$$

This expression describes the decay of a di-nucleus rotating with angular velocity $\omega = \ell\hbar/\mu R^2$ where μ represents the reduced mass of the system, ℓ its angular momentum (which should fall somewhere between grazing (ℓ_{gr}) and critical (ℓ_{cr}) angular momentum), R represents the distance between the two centres of the di-nucleus and t is the time interval during which the two nuclei remain in a solid contact in the form of the rotating di-nucleus. The value of 'life angle' α (= ωt) decides the time scale of the reaction. The time scales thus obtained are shown in Fig. 3 for a different fragments, emitted in the three different reactions. As found in a previous study[5], the time scales decrease as the fragment charges increase. This is expected because the heavier fragments nearer to the projectile require less number of nucleon transfer and therefore less time; on the other hand, the emission of lighter fragments requires exchange of more number of nucleons, and therefore longer times.

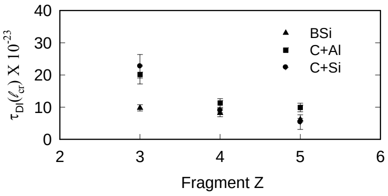

Fig. 3. Lifetimes of the di-nuclear systems for different emitted fragments.

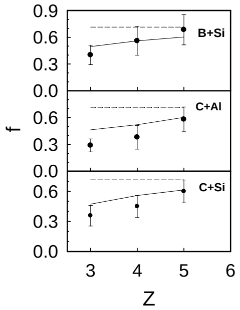

Fig.4.Variation of angular momentum dissipation factor *f* $(=\ell_f/\ell_i)$ with fragment Z.

As described in[6], the angular momentum dissipation factor *f* have been extracted for different systems and are displayed in Fig. 4 (filled circles) along with the rolling and sticking limit predictions (dotted and solid curves, respectively). It is apparent from Fig. 4 that for all the reactions considered, the experimental estimates of the mean angular momentum dissipation are near the sticking limit prediction. Further analysis is going on.

Reference

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