Deformation and orientation effects in the binary symmetric decay of $^{20,21,22}Ne^*$

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Introduction

We have extended the study of binary symmetric decay (BSD) of extremely light mass compound systems $^{20,21,22}Ne^*$ formed in $^{10,11}B$+$^{10,11}B$ reactions at $E_{lab} = 48$ MeV, to explore the role of deformations and orientations, using the Dynamical Cluster decay Model (DCM) of Gupta and collaborators [1–3]. The results are compared with purely spherical consideration of nuclei to bring out the effects of oriented nuclei as well as with that of our earlier study [2] having spherical consideration within the description of Süsmann central radii $C_t = C_1 + C_2$, to assimilate the deformation effects, where $C_i = R_i - b^2/R_i$ (in fm) with $R_i = [1.28A_i^{1/3} - 0.76 + 0.8A_i^{1/3}][1 + 0.0007T^2]$ fm and surface thickness parameter b=0.99 fm.

Our earlier studies [2] for the BSD of $^{20,21,22}Ne^*$ systems reveals fusion-fission σ_{ff} and deep inelastic orbiting σ_{DIO} contributions from compound nucleus CN and non-compound nucleus nCN processes, respectively, in the total DCM calculated BSD cross sections σ_{BSD}^{DCM}. On the basis of preformation probabilities (Fig. 1(a-c)), we noticed that the BSD of ^{20}Ne* is highly favored whereas for ^{21}Ne* there is strong competition from neighbouring fragments, whereas for ^{22}Ne* BSD is least favored. It pointed that nuclear structure is playing significnt role in BSD of these systems and further emphasized that the process of collective clusterization is playing very strong role within the DCM. In the present work [3], we find that with inclusion of quadruple deformations and "hot compact" orientations of nuclei σ_{ff} increases in comparison to the case of spherical considerations of nuclei.

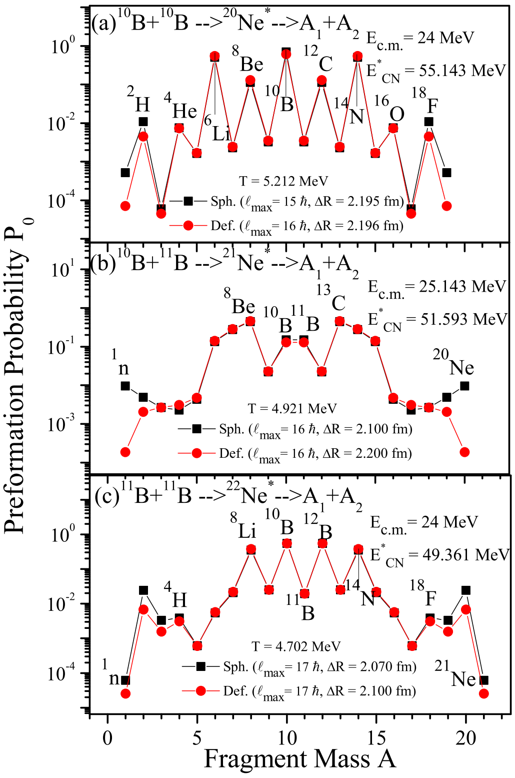

FIG. 1: Preformation Probability P_0 as a function of fragment mass A for the decay of a) ^{20}Ne*, b)^{21}Ne*, and c) ^{22}Ne*, at respective ℓ_c for spherical and oriented nuclei considerations.

Methodology

The decay of hot and rotating compound nucleus is studied within framework of dynamical cluster decay model (DCM), which is worked out in terms of collective coordinates of mass asymmetry η = (A$_T$-A$_P$)/(A$_T$+A$_P$)

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TABLE I: The BSD cross-sections calculated with ℓ summed upto ℓ_c for the decay of compound systems ^{20}Ne*, ^{21}Ne*, and ^{22}Ne*, using the DCM, alongwith their comparison with the experimental data [4].

					σ_{BSD} (mb)			
					DCM			
System	*Parameter*	ℓ_c ($\hbar$)	ΔR_{ff}(fm)	ΔR_{DIO}(fm)	*ff*	*DIO*	Total	*Expt.*
^{20}Ne*		15	2.195	1.683	236.46	33.30	269.76	~ 270
^{21}Ne*	$R_t + \Delta R$	16	2.100	1.574	102.60	27.37	129.97	< 130
^{22}Ne*	(*Sph.*)	17	2.070	1.605	8.52	60.48	69.0	< 70
^{20}Ne*		12	1.490	0.880	195.27	105.21	300.48	~ 270
^{21}Ne*	$C_t + \Delta R$	13	1.390	0.725	65.723	93.02	158.74	< 130
^{22}Ne*		14	1.490	0.690	8.677	88.62	97.297	< 70
^{20}Ne*		16	2.196	1.333	267.78	2.11	269.89	~ 270
^{21}Ne*	$R_t + \Delta R$	16	2.200	1.632	103.62	26.26	129.88	< 130
^{22}Ne*	(*Def.*)	17	2.100	1.643	8.68	59.34	68.02	< 70

and relative separation (R) with effects of temperature, deformation and orientation duely incorporated in it. In terms of these collective coordinates, using the ℓ- partial waves, the decay cross-section is defined as

$$\sigma = \frac{\pi}{k^2}\sum_{\ell=0}^{\ell_c}(2\ell+1)P_0P;\ k=\sqrt{\frac{2\mu E_{c.m.}}{\hbar^2}} \quad (1)$$

where preformation probability P_0 refers to η motion and is given by sol. of stationary Schrodinger eq. in η. Penetrability P refers to R motion and is calculated using WKB approximation, μ is the reduced mass and ℓ_c, the critical angular momentum.

Calculations and discussions

Fig. 1 (a-c) gives preformation probability P_0 as a function of fragment mass A for $^{20}Ne^*$, $^{21}Ne^*$ and $^{22}Ne^*$, resectively. The comparison between considerations of purely spherical and oriented nuclei gives similar results as it is evident from Fig. 1 as well as Table. 1. As we also found in our earlier study [2], the BSD for $^{20}Ne^*$ is highly favored followed by $^{21}Ne^*$ and least favored in case of $^{22}Ne^*$. Hence it is very much evident that the nuclear structure effects are playing an important role, within DCM, via preformation probability of different fragments prior to their decay.

Table. 1 presents the comparative analysis of total σ_{BSD}^{DCM} with the $\sigma_{BSD}^{Expt.}$ data for pure spherical, spherical (C_t+ΔR) and oriented nuclei considerations. The contribution of σ_{DIO} is calculated by considering the P_0= 1 for incoming channel i.e. the incoming nuclei are considered not to lose their identity. We note that for oriented nuclei consideration, the σ_{ff} contribution is more in comparison to the spherical consideration of fragments particularly for $^{20}Ne^*$ system. The results with the considerations of purely spherical and oriented nuceli show good agreement with the experimental data [4].

Acknowledgments

B.B.S. acknowledges the support by the DST, New Delhi, in the form of a Young Scientist Award under the SERC-FT Scheme, vide letter No. SR/FTP/PS-013/2011.

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