Alpha-nucleus *vs.* exotic clusters in the decay of excited compound nucleus ^{124}Ce* formed in ^{32}S+^{92}Mo reaction

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Introduction

In a recent experiment [1], ^{124}Ce*, formed in ^{32}S+^{92}Mo reaction at a beam energy of 150 MeV, is studied for its decays to various heavy-mass evaporation residues, like ^{121}La, $^{120-122}$Ba, $^{118-121}$Cs, $^{117-120}$Xe, ^{117}I, and ^{114}Te, which refer to complementary light particles (LPs) A≤4, Z≤2 and intermediate mass fragments (IMFs) 5≤A≤10, 3≤Z≤6. Since ^{124}Ce is a proton-rich nucleus, the decay products ^{120}Xe, ^{121}Cs and ^{122}Ba are observed, respectively, due to the evaporation of 4p, 3p and 2p, and with enhanced cross-sections. ^{118}Xe residue, which refers to exotic ^{6}Be cluster, is also observed with large cross-section, though its decay mechanism is not fully established. Interestingly, ^{116}Xe (equivalently, α-nucleus, ^{8}Be cluster) decay is not observed in this experiment. Application of the PACE4 statistical code to this data shows large deviations in the all above noted cases of proton clusters (4p, 3p, 2p), as well as the ^{118}Xe residue, i.e., ^{6}Be cluster decay.

Theoretically, ground-state (T=0) decay of ^{124}Ce and other neighboring nuclei is studied by Gupta *et al.* [2] on the basis of preformed cluster model (PCM) of Gupta and Malik, and showed a clear preference for A=4n, α-nuclei, like ^{4}He, ^{8}Be, ^{12}C, etc. It will thus be interesting to explore the decay mechanism of excited compound nucleus (CN) ^{124}Ce* and check the relative production of A=4n, α-nucleus like ^{8}Be *vs.* A≠4n, exotic cluster like ^{6}Be.

In this contribution, we take up this study on the basis of the dynamical cluster-decay model (DCM) of Gupta and Collaborators [3, 4], an extension of PCM to hot (T≠0) CN.

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The dynamical cluster-decay model (DCM)

In DCM, the decay of excited CN is studied as a collective cluster-decay process for the emission of LPs, IMFs and fission fragments, i.e., all decay products are treated as cluster emissions, in contrast to statistical models where each type of emission (LPs, IMFs or fission) is treated on a different footing.

The decay of hot and rotating CN in the DCM is worked out in terms of the decoupled relative separation R and mass asymmetry η [$=(A_1-A_2)/(A_1+A_2)$] coordinates, defining the CN decay cross-section as

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

Here, P_0 is the preformation probability, referring to η-motion and P, the penetrability, to R-motion. μ is the reduced mass and ℓ_{max} is the maximum angular momentum, defined for LPs evaporation residue (ER) cross-section $\sigma_{ER}\rightarrow 0$. In DCM, the structure effects of the CN are introduced through preformation probabilities P_0 of the fragments, given by the solution of stationary Schrödinger equation in η, and P is the WKB penetrability of the preformed fragments. The only parameter of the model is the neck-length parameter ΔR, defined by the first turning point of the WKB integral, as $R_a=R_1+R_2+\Delta R$ whose value remains within the range of validity (∼2 fm) of nuclear proximity potential used here.

Calculations and Results

Fig. 1 and Fig. 2 show our calculated P_0 and P as a function of light-mass fragment A_2 at three illustrative ℓ values. Fig. 1 shows that ^{8}Be lies higher than ^{6}Be for all the ℓ values, indicating that ^{8}Be is more strongly pre-

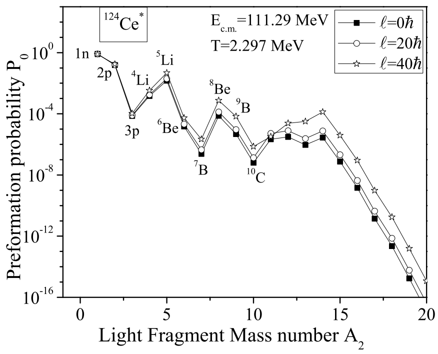

FIG. 1: Preformation probability P_0 as a function of light-fragment mass number A_2 for decays of ^{124}Ce* formed in ^{32}S+^{92}Mo reaction at $E_{c.m.}$=111.29 MeV for three different ℓ values.

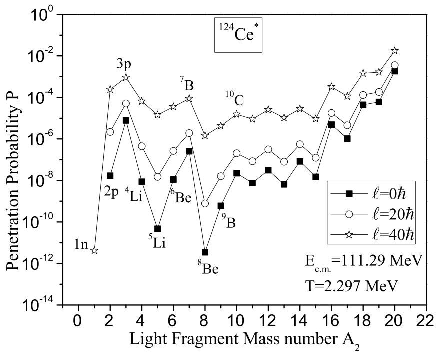

FIG. 2: Same as for Fig. 1, but for penetrability P.

formed than ^{6}Be. Note that ℓ_{max}=72 $\hbar$ and the plots in Figs. 1 and 2 are only at lower ℓ-values since it is known that lower ℓ values contribute to LPs and light-mass frragments, and the higher ℓ-values to fission region, and here we are interested in light-mass fragments only. In Fig.2, the penetration probability does not seem to contribute much (except for magnitude) since it is almost of the same order for all the fragments of interest here.

Table 1 shows our DCM calculated cross-sections compared with experimental data [1], given relative to ^{120}Cs (equivalently, ^{4}Li). For the best fitted LPs (masses 1-5) and ^{6}Be cross-sections, it is shown that the ^{6}Be and ^{8}Be cross-sections are comparable, and ^{8}Be is relatively more strongly populated than ^{6}Be at $E_{c.m.}$=111.3 MeV (T= 2.297 MeV), as has been found to be the case for ground state (T=0) decay [2].

TABLE I: DCM calculated relative cross-sections σ(Channel)/σ(^{120}Cs), in the decay of $^{124}Ce^*$ formed in ^{32}S+^{92}Mo reaction, compared with the experimental data [1] at $E_{c.m.}$=111.29 MeV (T= 2.297 MeV).

Decay-channel		ΔR	σ(Channel)/σ(^{120}Cs)	
Light	Heavy	(fm)	Cal.	Expt.
2p	^{122}Ba	0.15	0.44	0.46
3p	^{121}Cs	0.793	1.19	1.19
^{4}Li	^{120}Cs	0.575	1.0	1.0
^{5}Li	^{119}Cs	0.37	0.18	0.18
^{6}Be	^{118}Xe	1.0	1.63	1.63
^{7}B	^{117}I	1.0	0.07	0.41
^{8}Be	^{116}Xe	1.0	3.28	-
^{9}B	^{115}I	1.0	0.15	-
^{10}C	^{114}Te	1.0	0.004	0.24

Concluding, we have shown that CN ^{124}Ce* decays more preferably via A=4n, α-nucleus, as compared to exotic non-α nucleus decays. In other words, the preference for α-nuclei does not seem to change in going from ground-state to hot CN decays.

Acknowledgment

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References

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