# Decay of $^{118,122}$Ba formed in $^{78,82}$Kr + $^{40}$Ca reactions at beam energy 5.5 MeV/A

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## Introduction

Heavy ion induced reactions provide an alternate to explore the response and behavior of a nuclear system formed under the influence of variety of interactions. The regime of warm medium-mass(A∼100-130) compound nuclei formed in fusion reactions at incident energies below 10MeV/nucleon have been of much interest from time to time. With the availability of neutron rich beam, the GANIL experiment was performed at a lower energy of 5.5 MeV/A for $^{78,82}$Kr on $^{40}$Ca target[1]. The capture cross section (the sum of fission cross section and the evaporation residue (ER) cross section), kinetic energies and angular distributions of fragments were measured. The interesting aspect of this work is that, in addition to the total experimental fission and ER cross sections, the cross section for fragments with 3≤Z≤28 emitted in $^{78,82}$Kr on $^{40}$Ca reactions are also made available. In the present work we intend to study the decay of $^{118,122}Ba^*$ formed in $^{78,82}$Kr + $^{40}$Ca reactions using the Dynamical Cluster Decay Model (DCM) of Gupta and collaborators [2]. Earlier application of the DCM was made [3] to the preliminary data [4] for $^{118,122}Ba^*$. The preliminary data is lower in magnitude by a factor of 3-4 (i.e the newer data is having values approximately 3 to 4 times that of the one reported in [4]). The aim of present work is to study the fragmentation path of $^{78,82}$Kr + $^{40}$Ca reactions and explore the possible role of deformations, temperature, angular momentum, barrier modification etc. in context of reactions under study.

## The Model

The DCM [2]uses the collective coordinates of mass asymmetry $\eta = \frac{A_1 - A_2}{A_1 + A_2}$ and relative separation R, which allows to define the compound nucleus decay cross sections in terms of the partial waves as ;

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

with $\mu$ as the reduced mass and, $l_{max}$, the maximum angular momentum, fixed for the light particle cross section $\sigma_{LP} \rightarrow 0$. $P_o$, the preformation probability, is the solution of stationary schrodinger equation in mass asymmetry coordinate $\eta$ and P is the WKB penetrability of preformed fragments in R-motion. It is important to note here that preformation probability $P_o$ imparts the important nuclear structure information which is otherwise missing in the competing statistical models. In the frame work of DCM, the complete fusion cross-section is defined as $\sigma_{CF} = \sigma_{ER} + \sigma_{fission} + \sigma_{qf}$ where $\sigma_{CF}$, $\sigma_{ER}$, $\sigma_{fission}$, $\sigma_{qf}$ refer to complete fusion, evaporation residue, fission and quasi fission cross sections respectively. For qf, the preformation probabiity $P_0$=1 in DCM.

## Calculations and Discussions

The reactions $^{78,82}$Kr + $^{40}$Ca have been studied at incident energy of 5.5 MeV/A ($E_{cm}$=145.42 and 147.87 MeV respectively). We have fitted the available data for fission and ER cross sections simultaneously by fitting the neck length parameter ( △R) of the model. In agreement with experimental predictions, we also find some quasi fission contribution in available fission data (Pl. see Table1). The data of GEMINI and DNS code is also available for the ER and fission part, where the GEMINI code is clearly overestimating the fission data and underestimating

TABLE I: Evaporation residue and fission like cross sections for $^{78,82}$Kr + $^{40}$Ca reactions

| | $\sigma_{ER}$ (mb) | | | $\sigma_{fission}$(mb) | | | |
|---|---|---|---|---|---|---|---|
| | DCM | | Expt. | DCM | | Expt. | $\sigma_{Total}(DCM(sph))$ |
| | sph | def | | sph | def | | $(\sigma_{fission}+\sigma_{qf})$ |
| $^{118}$Ba | 538 | 539 | 539±100 | 318 | 101.4 | 447±46 | 447(318+129) |
| $^{122}$Ba | 491 | 490 | 492±90 | 296 | 139.2 | 332±35 | 331.2(296+35.2) |

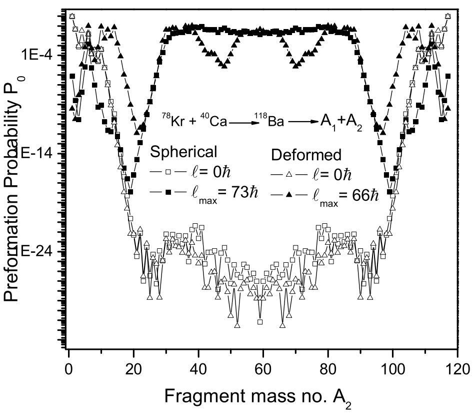


FIG. 1: Preformation probability as a function of fragment mass for compound systems $^{118}$Ba formed in $^{78}$Kr + $^{40}$Ca reaction at extreme $\ell$ values for spherical and deformed case.

the ER data and the DNS code is overestimating the ER data and underestimating the fission data. However within DCM approach, as clear from Table1, we are able to account reasonably for both the ER and the fission part by taking the spherical choice of fragmentation. However the moment we include the role of deformations, we are able to fit the ER data only but fails to account for the fission data. This implies that the role of deformation is explicitly present in the ER part. Fig.1 shows the preformation probability $P_0$ as a function of fragment mass $A_2$ at two extreme $\ell$- values for spherical and deformed choices for $^{78}$Kr + $^{40}$Ca reaction. It can be seen from the Fig.1 that at $\ell$=0$\hbar$ the behaviour is similar for the spherical as well as the deformed choice however at $\ell$=$\ell_{max}$, there seems a humped structure for the deformed choice and symmetric for the spherical i.e a single window is formed for the spherical case whereas multiple windows are apparent for the deformed case. A similar result is obtained for $^{122}$Ba. The individual fragment cross section data is also available, and in order to fit the individual fragment cross section, the choice of taking two $\triangle$R's (one for ER and other for fission) does not work. Therefore different $\triangle$R values are taken into consideration for different mass regions. The different mass regions are decided from the $P_0$ plot. The different values of $\triangle$R simply means that they are occuring at different time scales. In summary, The DCM based calculation for ER cross-sections and fission cross-sections show nice agreement with the available experimental data when we considered the spherical approach in fragmentation process. A significant qf seems to contribute towards fission cross sections, in agreement with experimental observation.

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