# Role of short and long range interactions in $4n$-decay channel of $^{266}$Rf* nucleus

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## Introduction

The interaction potential has paramount importance in the heavy ion reaction dynamics. The knowledge of the short and long range interaction potentials is immensely desirable to understand the heavy ion collisions and subsequent decay patterns. In addition to the well known Coulomb potential which account for the charged particle interactions, the contributions of nuclear proximity and centrifugal potentials are of significant interest for overall understanding of nuclear dynamics in heavy and superheavy mass region.

The proximity potential arises when two surfaces approach each other within a distance of 2-3 fm. However, the centrifugal potential of the nucleus can be associated with the estimation of rotational energy component when the nucleons or the decaying fragments are excited and are governed via angular momentum. To explore the role of proximity and centrifugal parts of the total potential, the $4n$ neutron evaporation channel of $^{266}$Rf* nucleus formed in $^{18}$O+$^{248}$Cm reaction is studied in the framework of the dynamical cluster decay model (DCM)[1, 2] by using Prox-77 [3] and Prox-00 [4] with the inclusion of sticking ($I_S$) and non sticking ($I_{NS}$) moments of inertia in the beam energy range $E_{lab}$=88.2 to 94.8 MeV.

## The Model

The temperature dependent fragmentation potential comprises of binding energies, the Coulomb repulsive interaction, the additional attraction due to nuclear proximity force and the centrifugal potential due to angular momentum given by:

$$V_R(\eta,T) = -\sum_{i=1}^{2} B_i(A_i,Z_i,\beta_{\lambda i},T) + V_C(R,Z_i,\beta_{\lambda i},\theta_i,T) + V_P(R,A_i,\beta_{\lambda i},\theta_i,T) + V_\ell(R,A_i,\beta_{\lambda i},\theta_i,T) \quad (1)$$

The $T$-dependent nuclear proximity potential for deformed, oriented nuclei is given by

$$V_P(s_0(T)) = 4\pi\bar{R}(T)\gamma b(T)\Phi(s_0(T)), \quad (2)$$

where $b(T) = 0.99(1 + 0.009T^2)$ is the nuclear surface thickness and $\overline{R}(T)$ is the mean curvature radius. $\Phi$ in Eq. (2) is the universal function, independent of the shapes of nuclei or the geometry of nuclear system, but depends on the minimum separation distance $s_0(T)$. The details of prox-77 and prox-00 can be seen in [3] and [4] respectively.

The centrifugal potential is given as,

$$V_\ell(R,A_i,\beta_{\lambda i},\theta_i,T) = \frac{\hbar^2\ell(\ell+1)}{2I(T)} \quad (3)$$

with moment-of-inertia in sticking limit, defined as $I = I_S$=$\mu R^2$+$(2/5)A_1mR_1^2(\alpha_1,T)$+$(2/5)A_2mR_2^2(\alpha_2,T)$. On the other hand, moment-of-inertia in non-sticking limit is given by $I = I_{NS}$=$\mu R^2$.

## Calculations and discussion

To understand the effect of long range and short range potentials on the $4n$- decay channel of $^{266}Rf^*$ nucleus, the comparative analysis of Prox-77 and Prox-00 and centrifugal potential calculated using $I_S$ and $I_{NS}$ approach

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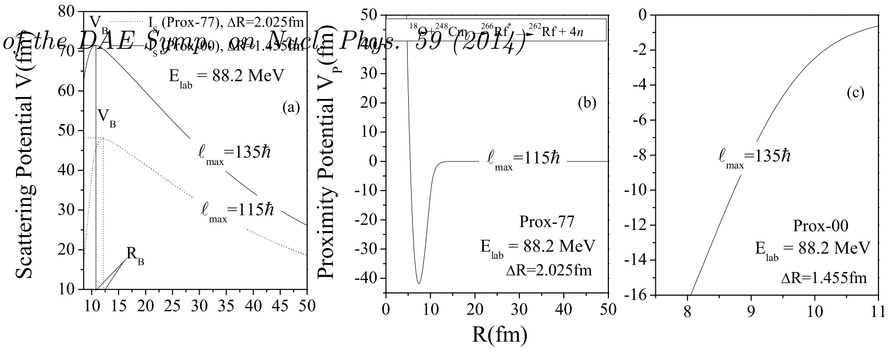


FIG. 1: (a) Comparison of scattering potentials for the use of Prox-77 and Prox-00 in $4n$-decay of $^{266}$Rf$^{*}$.(b) Prox-77 for the $4n$-decay (c) Prox-00 for the $4n$-decay.

is governed in the framework of DCM [1, 2]. In order to address the role of different proximity potentials, Fig.1 is plotted, in which the barrier characteristics of $4n$ decay channel are shown. Fig. 1(a), shows the scattering potentials ($=V_C+V_P+V_\ell$) for the use of two different proximity interactions, one can clearly see that both the barrier height ($V_B$) and barrier position ($R_B$) get modified by changing the proximity potential from Prox-77 to Prox-00. It is relevant to mention here that the consistency of above result is maintained if we make the comparison of barrier height at the same magnitude of neck length parameter ($\Delta R$) and maximum angular momentum ($\ell_{max}$). The difference in the barrier characteristics of prox-77 and prox-00 is mainly arises due to the different nature of prox-00 and prox-77, contributing to the total potential, as shown in the Fig. 1(b) and 1(c). The Prox-77 exhibits strongly repulsive proximity potential in overlapping region, and under similar conditions, is found to be far more attractive than Prox-00.

Further to observe the effect of centrifugal potential for the use of sticking and non-sticking moments of inertia on the decaying fragments, Fig.2 is plotted for light fragment mass at a fixed value of angular momentum $\ell$=23$\hbar$. It is evident from the figure that the major change in the structure and magnitude of the fragmentation potential is observed for the light particles, as compared to heavy mass fragment (HMF) and fission region. Fig.2 also signifies that for $4n$ decay channel, higher fragmentation potential is observed for the $I_{NS}$ approach as compared to the $I_S$. Hence one may say that the sticking moment of inertia ($I_S$) is more favorable for the $4n$ decay of $^{266}Rf^*$ nucleus as compared to the $I_{NS}$ approach.

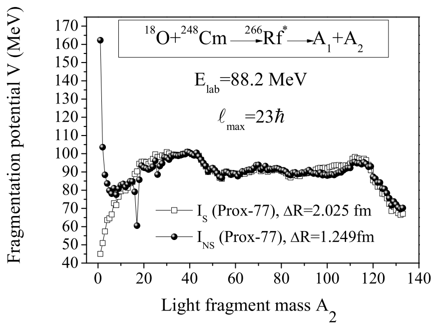


FIG. 2: Fragmentation potentials as a function of light fragment mass for the use of sticking and non sticking moments of inertia at $E_{lab}$=88.2 MeV.

In conclusion, the proximity and centrifugal potentials influence the fragmentation potential and barrier characteristics significantly. This in turn influence the neutron evaporation path of superheavy nuclear systems formed in heavy ion reaction.

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## References

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