Fusion excitation functions of ^{66}As* formed in ^{8}B + ^{58}Ni reaction at near barrier energies.

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Introduction

The study of proton-halo systems has become an interesting area of research in recent years. This is so because the knowledge of p-halo's is very scarce in comparison to neutron-halo systems. In view of having worthy information regarding nuclear structure and dynamics related to p-halo systems, the fusion of exotic p-halo ^{8}B nucleus with ^{58}Ni target has been studied. The experimental data for the fusion cross-sections of ^{8}B + ^{58}Ni$\rightarrow^{66}$As$^*\rightarrow A_1$+A_2 reaction has been reported at various energies around the Coulomb barrier [1]. The same is tested in framework of dynamical cluster decay model (DCM)[2] and the ℓ-summed Wong model [3]. Since the projectile involved is halo, the extended radius of halo nuclei is assimilated in DCM through the neck-length parameter ΔR. However, in Wong model calculations 26% increased radius is employed as suggested in experimental paper [1].

The Model

Dynamical cluster decay model (DCM): The DCM, carries distinct advantage over available statistical models as it treats the Evaporation Residue (ER), intermediate mass fragment (IMF) and fusion fission (ff) on equal footing [2]. The missing nuclear structure information of the Compound Nucleus in statistical models enters in the DCM via the preformation probability P_0 of the fragments and is calculated by solving stationary Schrödinger equation in η co-ordinate. For ℓ-partial waves, the compound nucleus decay cross-section is given by

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

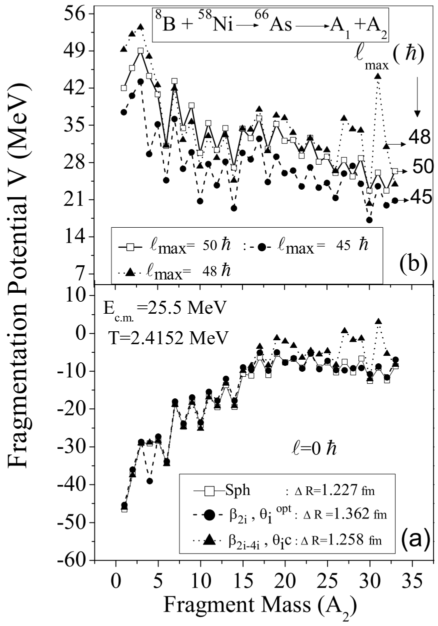

FIG. 1: Variation of fragmentation potential with fragment mass A_2 at (a) ℓ=0$\hbar$ and (b) ℓ=ℓ_{max}

where $\mu = [A_1A_2/(A_1+A_2)]m$ is the reduced mass, m is the nucleon mass, and ℓ_{max} is the maximum angular momentum. The angular momentum ℓ_{max} is fixed for the vanishing of the fusion barrier of incoming channel η_i or light particle cross-section $\sigma_{LP}\rightarrow 0$. The preformation probability P_0 refers to η motion and the penetrability P to R motion, both depending on angular momentum ℓ and temperature T of compound nucleus state. The DCM has been used to study the decay of ^{66}As* in terms of light particles (LPs), intermediate fragments (IMFs) and the fission fragments.

The ℓ-summed Wong model: The extended ℓ-summed Wong Model is a special case of DCM where cross-sections are cal-

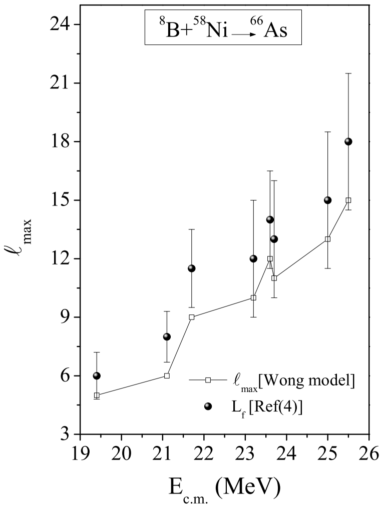

FIG. 2: Deduced ℓ_{max} values using ℓ-summed Wong model.

culated through Eq.(1), by taking P_0=1 and penetrability P calculated in Hill-Wheeler approximation, which in DCM is calculated by the WKB integral for each decay channel. The penetrability P, in terms of the barrier height V_B and curvature $\hbar\omega_\ell$, is given as

$$P = \left[1 + \exp\left(\frac{2\pi(V_B - E_{c.m.})}{\hbar\omega_\ell}\right)\right]^{-1} \qquad (2)$$

with $\hbar\omega_\ell$ evaluated at the barrier position $R = R_B$ corresponding to barrier height V_B.

Calculations and Discussions

The fusion excitation function have been calculated for the reaction in which exotic proton-halo nucleus ^{8}B is incident on a ^{58}Ni target at several energies near the Coulomb barrier [1], using dynamical cluster-decay model (DCM) and ℓ-summed Wong model. In framework of DCM, the fusion cross-section is the sum of decay processes involving ER, IMFs, and fission fragments, and the calculations have been done for spherical, β_2 deformed and β_2-β_4 deformed choice of fragmentation. At $E_{c.m.}$=25.5 MeV, the fusion cross-section of 864.67mb has been fitted within one parameter of DCM, the neck-length parameter $\triangle R$. The cross-section of LPs is 333.55mb, IMFs is 445.73 mb and that of fission fragments is 84.52 mb. Similar trend of decay cross-sections is observed at all other energies. These results help us to conclude that IMFs are the major contributors towards the decay of ^{66}As* followed by LPs and only 10% contribution is through fission. As shown in Fig.1 (a) and (b), the fragmentation path is almost independent of deformation effects for ℓ=0$\hbar$. However, at ℓ=ℓ_{max} the potential energy surfaces get influenced with the inclusion of deformation and orientation effects. The fragmentation is more prompt for β_2 deformation. Besides this, DCM has also been tested for one of non-compound nucleus process i.e the incomplete fusion (ICF). In this case the break-up of ^{8}B into ^{7}Be is observed, which in turn interact with the target ^{58}Ni. After applying appropriate energy correction the decay cross-section for ^{8}B+ ^{58}Ni→^{65}Ge*→A_1+A_2 are calculated. The results obtained (for β_2 deformed case) are in agreement with the ones reported in [1]. Finally, the fusion cross-sections have also been calculated by extended-Wong model. The cross-sections have been fitted at all the energies except one lying below the barrier as it requires modification at below barrier region. The deduced ℓ-values from Wong calculations are in good agrement with those of L_f-values extracted from the fusion data as is clear from Fig.2. The ℓ-values in case of DCM are relatively of higher magnitude because sticking moment of inertia is used in these calculations to account for proximity interaction. In summary the fusion-fission cross-section compare nicely with experimental data. The role of deformation is seen in decay of $^{66}As^{*}$ and the contribution of IMFs is found to dominate, followed by LPs and fission.

References

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