Theoretical quasi-elastic excitation function and barrier distribution with various diffuseness parameters for $^{16}O+^{116}Sn,^{176}Yb$

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Introduction

To describe a nuclear collision, the nature of potential between colliding nuclei is important. The potential barrier between the colliding nuclei is created due to repulsive Coulomb force and the short range attractive nuclear interactions. According to Eigen Channel approximation, the potential barrier splits into a distribution of barrier due to the coupling of relative motion of intrinsic degrees of freedom. This nature of potential can be studied by studying the fusion or quasi-elastic scattering (QES) excitation function. The sum of elastic, inelastic and transfer reaction is equal to QES. Fusion is related to transmission probability and QES is related to reflection probability. Fusion barrier distribution (D_{fus}) can be extracted from the fusion excitation function σ ($E_{c.m.}$) by taking the second derivative of $E_{c.m.}$, i.e. $d^2(E_{c.m.}.\sigma(E_{c.m.}))/dE^2_{c.m.}$. This method was first proposed by Rowley et al. [1]. But QE barrier distribution (Dq) is extracted from the first derivative of the QES excitation function ($d\sigma_q/d\sigma_R$) which is given by $-d(d\sigma_q/d\sigma_R)/dE$. Timmers et al. first proposed this method [2]. σ_q and σ_R are QES cross section and Rutherford scattering cross section. In QES measurement even lesser precise data can be utilized as compared to that of the fusion measurement as in the expression of barrier distribution; fusion has double derivative and QES has single derivative with respect to energy [3]. QES barrier distribution is an important parameter to study the super heavy elements as it carries significant information regarding to it [4]. To such QES excitation function, theoretically, the couple channel calculations can be performed using various combinations of target and projectiles by scattering version of CCFULL [5]. The barrier distribution can be calculated using the method describe above. In the scattering version CCFULL program, nuclear potential has real and imaginary component which is assumed to have Wood-Saxon (WS) form. The parameter associated with the potential can be used to study the various effects. In this paper, an attempt is being made to study the effect of diffuseness parameter and the WS potential parameter in excitation function of $^{16}O+^{116}Sn$, ^{176}Yb below the Coulomb barrier from energy range of 40-70 MeV and 60-90 MeV respectively at a scattering angle of 150^0.

Table 1: Wood-Saxon parameter for $^{16}O+^{116}Sn$

V_0 (Mev)	r_r(fm)	a_r(fm)	W_0 (MeV)	r_i (fm)	a_i (fm)
105	1.1	0.75	30	1.0	0.6
95	1.0	0.65	25	1.2	0.55
80	1.2	0.45	20	1.2	0.4

Results and Discussions

The interaction potential (V) for projectile and target is the sum of the long-range coulomb potential (V_C), centrifugal potential (V_{CEN}) and the short-range nuclear potential (V_N).

$$V = V_C + V_N + V_{CEN}$$

where, $$V_C = \begin{cases} \frac{Z_T Z_P e^2}{2r_c}\left(3 - \frac{r^2}{r_c^2}\right) & if\ r \le r_c \\ \frac{Z_T Z_P e^2}{r} & if\ r > r_c \end{cases}$$

$$V_N = -\frac{V_0}{\left(1-e^{-\frac{r_r - R}{a_r}}\right)} - i\frac{W_0}{\left(1-e^{-\frac{r_i - R}{a_i}}\right)}$$

$$V_{CEN} = l(l+1)\hbar^2/2\mu r$$

Here V_0, W_0, r_r and r_i are the Wood-Saxon potential parameters where as a_r and a_i are the

respective real and imaginary diffusion parameters. The first term in V_N represents real potential which says about reflection and the second term represents imaginary potential which gives absorption. We extracted excitation function and barrier distribution for various diffusion parameters in this WS potential for $^{16}O+^{116}Sn$, ^{176}Yb. In this paper, we have shown three values of diffusion parameters, but actually we have done our calculations at several values ranging from 0.45 to 0.75. The WS potential parameters used in the calculation for the systems are given in the Tables 1 and 2.

Table 2: Wood-Saxon parameter for $^{16}O+^{176}Yb$

V_0 (Mev)	r_r (fm)	a_r (fm)	W_0 (MeV)	r_i (fm)	a_i (fm)
105	1.1	0.75	30	1.0	0.35
95	1.0	0.60	25	1.1	0.5
80	1.2	0.40	20	1.2	0.4

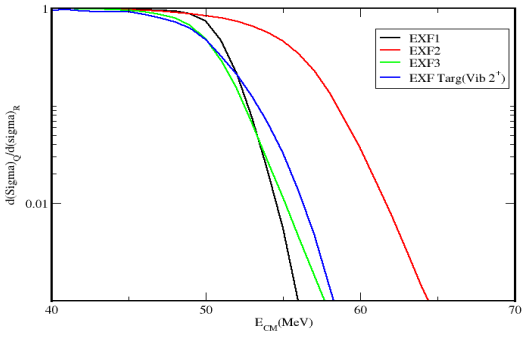

Fig. 1 Excitation function of $^{16}O+^{116}Sn$

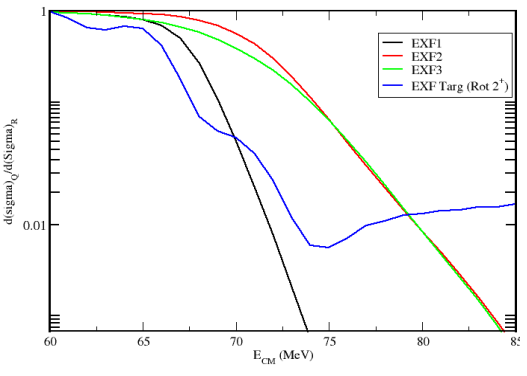

Fig. 2 Excitation function of $^{16}O+^{176}Yb$

The excitation functions and the barrier distributions are given in the following Figs. 1-4.

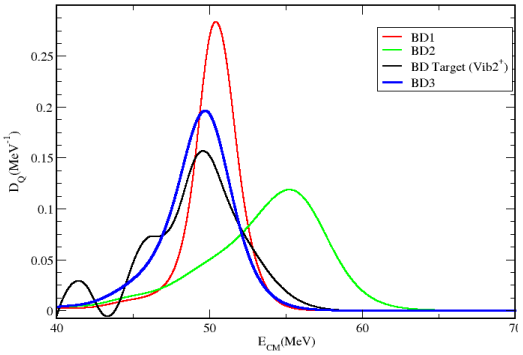

Fig. 3 Barrier distribution of $^{16}O+^{116}Sn$

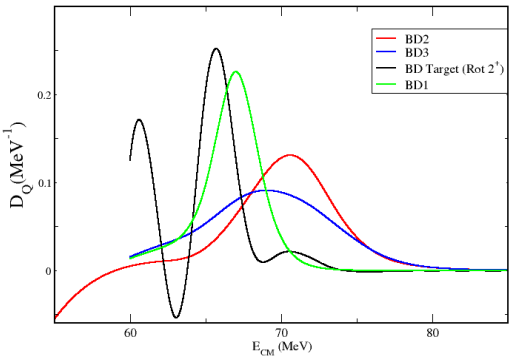

Fig. 4 Barrier distribution of $^{16}O+^{176}Yb$

Conclusions

It is seen that the potential parameters affects the reaction and the barrier distribution peak shifts towards higher energy on decreasing the diffuseness parameter. More discussion on the potential parameters will be highlighted in the symposium. Studies have been done for spherical and deformed system. In future, the effect of inelastic and transfer couplings would be seen in barrier distribution.

References

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