Effect of Coulomb breakup on the fusion of ^{11}Li+^{208}Pb system around the barrier energies

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The fusion reactions of loosely bound radioactive ions with the stable targets are of immense importance in conjugation with the production of super heavy elements and the reactions of astrophysical interest. However, owing to the small binding energy of last nucleon(s) the breakup greatly affects the fusion cross section involving these nuclei. So far, many efforts have already been made to investigate these effects on the fusion cross section but the controversial results regarding these effects have been found as reported in the literature [1].

Here we have used the dynamic polarisation potential (DPP) approach to study the Coulomb breakup effect on fusion of weakly bound nuclei [2,3]. The l-dependent Coulomb dipole induced dynamic polarisation potential is given by

$$U_l^{bu}(r) = -i\frac{4\pi\mu(Z_T e)^2 B_{cl}(E1)\uparrow}{9\eta\hbar^2}\frac{|S^{opt}|}{1+\bar{l}^2}\left(\frac{1}{r^2}+\frac{\bar{l}^2}{\eta k r^3}\right) \quad (1)$$

and is utilised to calculate the breakup transmission co-efficient T_l^{bu} via

$$T_l^{bu} = 1 - exp\left[-2\int_{\rho_0}^{\infty}\frac{Im U_l^{bu}/E_{c.m.}}{\sqrt{1-2\eta/\rho - l(l+1)/\rho^2}}d\rho\right] \quad (2)$$

All the symbols used in this expression are same as defined in reference [4]. The so obtained breakup transmission coefficient is used to investigate the effect of breakup channel coupling on the fusion cross section by employing the following relation

$$\sigma_f^{coup} = \frac{1}{2}\frac{\pi}{k^2}\left[\left(\sum_{l=0}^{\infty}(2l+1)\sqrt{1-T_l^{bu}}\,T_l^f(+F)\right) + \left(\sum_{l=0}^{\infty}(2l+1)\sqrt{1-T_l^{bu}}\,T_l^f(-F)\right)\right] \quad (3)$$

where F is the channel coupling strength which is taken as a free parameter.

The barrier parameters i.e. barrier height and barrier radius, needed in the calculations, are obtained by plotting the effective potential as shown in Fig.1 and for the system considered here have been found as 22.35 *MeV* and 15.0 *fm* respectively. While the barrier curvature is taken from Ref. [5]as $\hbar\omega = 3.0\,MeV$.

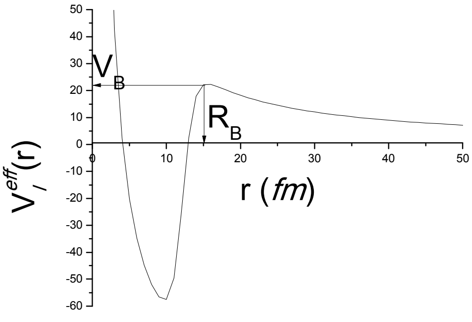

Fig.1 Effective potential for ^{11}Li + ^{208}Pb system.

In Fig.2 the breakup transmission factors for ^{11}Li + ^{208}Pb system are shown corresponding to the different number of partial waves. It is clear in this figure that in the sub-barrier energy regime the magnitude of breakup transmission coefficient is maximum when only the s-wave is taken into account, while at above barrier energies it reduces to zero for all partial waves. The finite value of the quantity T_l^{bu} at deep sub-barrier and around the barrier energies signifies the importance of breakup effects. However as the incident energy is increased above the barrier the other reaction channels start competing with the breakup channel and finally at very high energies the breakup channel closes and the breakup transmission coefficients become zero.

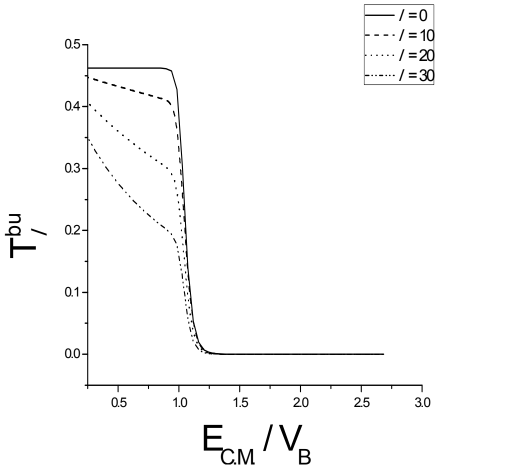

Fig.2 Breakup transmission coefficients corresponding to different number of partial waves for $^{11}Li + ^{208}Pb$ system.

In Fig. 3 the fusion cross section for ^{11}Li + ^{208}Pb system without (Hill-Wheeler) and with the breakup channel coupling effect arising because of the Coulomb dipole excitation are presented. In the sub-barrier energy regime it has been found that there is no substantial enhancement due to the breakup channel coupling as compared with the simple one dimensional barrier penetration model. On the other hand for higher energies well above the barrier there is a suppression of fusion cross section with respect to no coupling case.

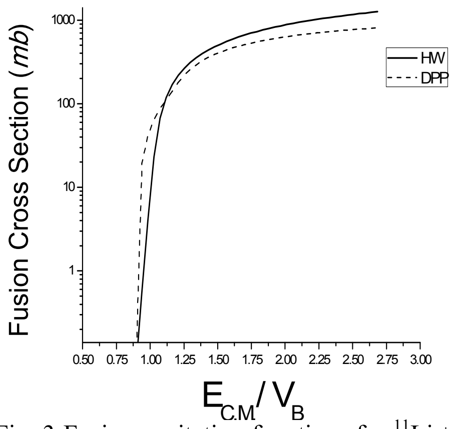

Fig. 3 Fusion excitation functions for $^{11}Li + ^{208}Pb$ system.

In conclusion we have studied the effect of Coulomb breakup on the fusion cross section for ^{11}Li + ^{208}Pb system at sub-barrier and above barrier energy regimes using the dynamic polarisation potential (DPP) approach. It is found that there is no substantial enhancement due to the breakup channel coupling in the sub-barrier energy regime while suppression is observed well above the barrier.

References

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