Angular momentum cut-off for fusion of weakly bound ^{7}Li with ^{165}Ho

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Fusion involving weakly bound stable and radioactive nuclei has drawn considerable interest in recent years [1]. Enhancement of fusion as compared to one dimensional barrier penetration model prediction due to coupling to their internal degrees of freedoms is well understood. Systems involving weakly bound stable nuclei have been reported to show overall fusion suppression in addition to the below barrier enhancement. Measured fusion cross sections for weakly bound radioactive ^{8}B ion on a ^{58}Ni target shows enhancement at all energies, rather than showing enhancement at below barrier energies only [1]. This enhancement has been attributed to a static halo effect associated to the extended size of the proton-halo state of ^{8}B.

Aguilera *et al.* [2] has recently proposed an analytical model for fusion of halo and weakly bound systems. This analytical model is an extension of the Wong model [3]. Wong model which was actually proposed for reaction cross-section, has been extensively used to analyze fusion data and extract fusion barrier parameters for systems involving tightly bound nuclei, as fusion is the dominant part of the reaction cross-section. However, in case of systems involving weakly bound nuclei, contribution of direct reaction channels to the reaction cross section are significant. Hence, application of Wong model to fit fusion excitation functions to extract barrier parameters may lead to ambiguous results.

According to the new analytical model [2], the fusion cross section is expressed as

$$\sigma_{fus} = \frac{\pi}{k^2}\sum_{l=0}^{\infty}(2l+1)T_l P_l. \quad (1)$$

The above expression is same as the Wong model expression with $P_l = 1$ for all l values. In the analytical model it is assumed that $P_l = 1$ for $l \leq L_f$ and $P_l = 0$ for $l > L_f$. This means only partial waves with l less than or equal to L_f (angular momentum limit to fusion) will contribute to fusion cross section.

Aguilera et al [2] have analyzed fusion data for several systems involving weakly bound stable / radioactive nuclei using the above mentioned analytical model and have extracted values of cut-off angular momentum, L_f. The extracted values of L_f were found to have a linear energy dependence :

$$L_f = A + B \times E_{c.m.} \quad (2)$$

where A and B are constant.

This assumption of having a cut-off angular momentum for fusion can be also verified by comparing it with the average angular momentum for fusion. In the present work we have compared average angular momentum of fusion from the analytical model with the extracted average angular momentum from the measured gamma ray multiplicity, ratio of partial evaporation residue and fit to the fusion excitation function for ^{7}Li+^{165}Ho system.

Balantekin and Reimer has given a prescription to calculate average angular momentum from the fit to fusion excitation [4]. This prescription has been used to calculate average angular momentum and they are found to be in good agreement with the average angular momentum obtained from multiplicity

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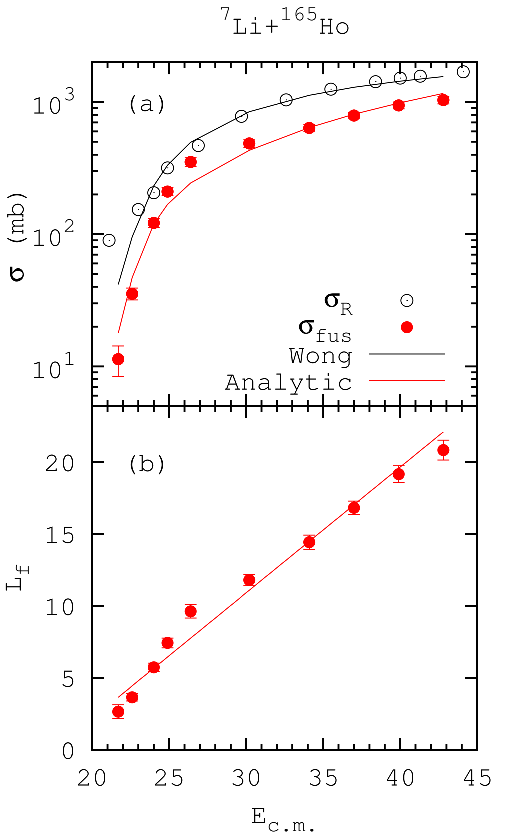

FIG. 1: (a) Total reaction σ_R and fusion data σ_{fus} for loosely bound system, ^{7}Li+^{165}Ho . The solid line corresponds to Wong model fit. (b) Angular momentum cut-off extracted from the fusion data of ^{7}Li+^{165}Ho along with a linear fit.

data for systems involving tightly bound nuclei [5]. Good agreement has been also found between the average angular momentum extracted from the fit to the fusion excitation function and the multiplicity data for weakly bound projectile ^{7}Li on ^{165}Ho target [6].

Fig. 1(a) shows the total reaction σ_R and fusion data σ_{fus} for the system, ^{7}Li+^{165}Ho along with the fits according to the analytical model. The extracted L$_f$ are plotted in Fig. 1(b) along with the linear fit. In Fig. 2, the average angular momentum from gamma ray multiplicity, ratio of evaporation residue [6]

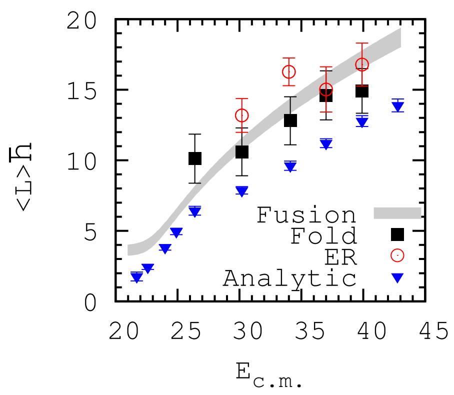

FIG. 2: Average angular momentum for ^{7}Li+^{165}Ho system. The average angular momentum from gamma ray multiplicity (fold) , ratio of evaporation residue (ER) and fit to fusion excitation function (grey band) are compared with those extracted from the analytical model.

and fit to fusion excitation function are compared with those extracted from the analytical model.

While the average angular momentum from gamma ray multiplicity, ratio of evaporation residue and the fit to fusion excitation function agrees well with each other, the average angular momentum extracted from the analytical model is found to be lower at all energies.

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