Analysis of complete fusion excitation functions for ^{7}Li+^{152}Sm, ^{197}Au and ^{209}Bi reactions at around barrier energies

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The study of nuclear reactions involving weakly bound nuclei at near barrier energies is a subject of contemporary interest. In particular because of the small binding energy of projectiles investigation of the role of breakup process on fusion excitation functions has attracted significant interest. The coupling with the breakup channel initiates new complete fusion (CF), incomplete fusion (ICF) and sequential complete fusion (SCF) processes which cause irregular enhancement in fusion excitation functions in sub barrier energy region and needs further investigation [1]. One of the major endeavors is to study the relative contribution of CF and ICF in total fusion cross section. In the present work we have analyzed the fusion excitation function for CF process using the simple Wong's formula in conjunction with the energy dependent Woods-Saxon potential (EDWSP) [2-4] in near barrier energy region for ^{7}Li+ ^{152}Sm, ^{197}Au and ^{209}Bi reactions. For detailed description of calculation methodology please see Ref. [2]. In order to extract CF from TF, we have used a recently proposed selection function [2] which represents the fact that at barrier energy, there is a strong competition between the CF and ICF processes as both are equally probable. While at energies much higher than the barrier energy, CF predominates over ICF and vice versa at very low energies.

Since the fusion cross section is highly sensitive to barrier radius, a very small change in its value may results appreciable change in fusion cross section. For the reactions considered here, barrier radius must depend on the deformation of target nucleus only because the quadrupole moment of the projectile ^{7}Li is negligibly small in comparison to that of target.

Phenomenologically, we have found that the parameter r_0 used to determine barrier radius varies from 1.38 to 1.39fm for reactions involving targets having quadrupole moment smaller than 0.5b, from 1.40 to 1.41fm for reactions involving targets with quadrupole moment 0.5 to1.5b and 1.42 to1.44fm for reactions involving targets with quadrupole moment greater than 1.5b.

In Figs. 1 through 3 we have compared the fusion excitation function for CF process for ^{7}Li+ ^{152}Sm, ^{197}Au, ^{209}Bi reactions respectively with the corresponding experimental data. The values of barrier radius parameter used in the calculation along with the quadrupole moment of targets are listed in Table 1. The quadrupole moment values are taken from Ref. [5] observed via Muonic X-ray hyperfine structure method. It is important to note that barrier radius parameter increase with the increase in absolute value of quadrupole moment of target and does not depend upon its sign. It may be attributed to the fact that the deformed target may have different orientations with equally likely.

Table 1 Values of quadruple moment and barrier radius parameter r_0 for targets considered in present study.

Nucleus	Quadrupole moment (barn)	Barrier radius parameter (fm)
^{152}Sm	-1.7	1.43
^{197}Au	0.6	1.40
^{209}Bi	-0.4	1.38

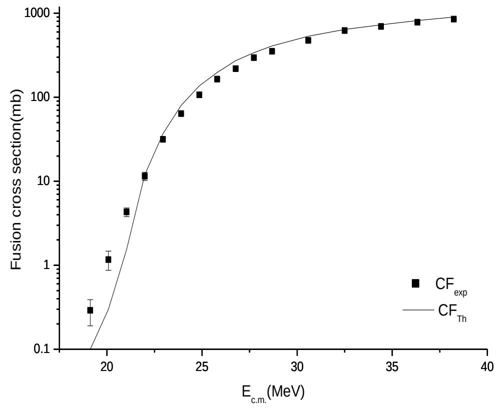

Fig. 1 *Complete fusion excitation function for* ^{7}***Li***+^{152}***Sm*** *reaction is compared with the experimental data taken from Ref. [6].*

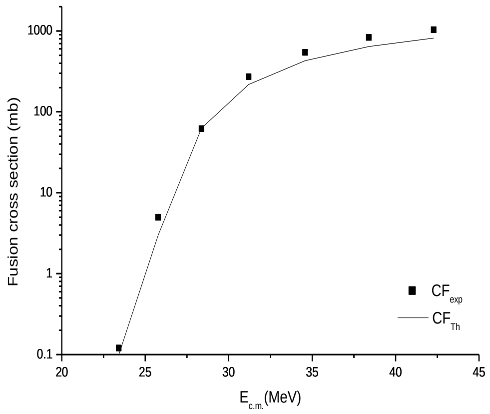

Fig.2 *Same as Fig. 1 but for* ^{7}***Li***+^{197}***Au*** *reaction. Experimental data are taken from Ref. [7]*

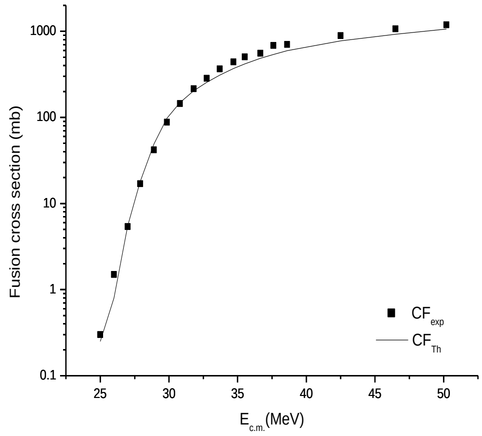

Fig.3 *Same as Fig. 1 but for* ^{7}***Li***+^{209}***Bi*** *reaction. Experimental data are taken from Ref. [8].*

It can be seen clearly in Figs.1-3 that by using these values of barrier radius parameter the data are reproduced reasonable well in around barrier energy region. It is worth mentioning that this systematics for determining barrier radius parameter has emerged through the analysis of fusion excitation functions of more than ten projectile target combinations. Nevertheless the functional form of the dependence of barrier radius on the deformation of colliding nuclei is needed to be developed.

References

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