Mass-number dependence of statistical model parameters and its impact on incomplete fusion fraction calculations

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(Received 6 April 2021; revised 20 July 2021; accepted 4 August 2021; published 14 September 2021)

Incomplete fusion processes and estimation of strength of incomplete fusion in heavy ion induced nuclear reactions have been explored for several combinations of projectile-target nuclei. Dynamics of these reactions is explained using an optical model. Parameters of the optical model affect the shape and depth of nuclear potential and hence influence the theoretical predictions. For heavy ion induced reactions, the optical model potential parameters are not unique and different sets of these parameters may be used for different ranges of mass number *A* and incident energy *E*. To explore the effect of optical model potential parameters, a comparative study of available experimental data for excitation functions of four systems, $^{16}O + {}^{181}Ta$, $^{12}C + {}^{165}Ho$, $^{14}N + {}^{163}Dy$, and $^{16}O + {}^{74}Ge$, with corresponding theoretically predicted excitation functions, made by PACE4 using different sets of optical model potential parameters, has been done. It has been observed that a single set of optical model potential parameters is not adequate for all the systems. The variations in these parameters change the theoretical cross-section predictions for various channels considerably, which in turn, change the correspondingly estimated fraction of incomplete fusion (F_{ICF}). The effect of deformation of target nuclei on fractional incomplete fusion has also been investigated for the above mentioned systems. F_{ICF} has been plotted as a function of deformation parameter (β_2) of the target nuclei and it is found to increase as the deformation parameter of the corresponding target nuclei increases on either side of the intrinsic spherical symmetry.

DOI: 10.1103/PhysRevC.104.034615

I. INTRODUCTION

Nuclear reaction studies play a vital role in exploring the universe and also in the modeling of various astrophysical phenomena. Neutron emission studies in cosmic sources like stars, supernovae explosions, etc. give valuable information about the origin of chemical elements, their isotopes, and the role of nuclear energy [1]. Scientists' quests to further discover new elements and to extend the periodic table by synthesis of heavier elements, not found naturally, has further enhanced the role of nuclear reaction studies induced by heavy ions (HIs). Interaction studies using a wide range of projectiles, from neutrons to heavy nuclei, with different targets have been used to explore the nuclear reaction mechanisms and complexity of nuclear structures in a wide range of incident energies. Investigation of different modes of HI induced nuclear reactions at energies $\leqslant$7 MeV/nucleon has been a topic of considerable interest during the last few decades [2–9]. Out of various modes of reactions, complete fusion (CF) and incomplete fusion (ICF) reactions play a significant role to explore the hidden features of nuclear structure and complex mechanisms of HI induced reactions [10–14]. The topic of incomplete fusion in heavy ion reactions has been studied in detail [15–18], although the theory did not make progress since the studies of Wilczynski [19,20] and work done by Diaz-Torres [21]. The effects of various entrance channel parameters like projectile energy, mass-asymmetry (μ_A) of interacting nuclei, α-Q value, input l value, deformation parameter (β_2), etc., on the ICF processes have been studied by various groups [22–24]. The presence of ICF in the reaction systems has been probed within the framework of different statistical model based computer codes, PACE4 [25] being one of them. PACE4 is based on the Hauser-Feshbach (HF) theory of compound nucleus decay and calculates nuclear reaction cross section using the Bass formula. The code calculates transmission coefficients (TCs) for neutron (n), proton (p) and alpha particles (α) using the optical model [26]. In this code, the nuclear level density parameter a ($a = A/K$ MeV^{-1}, where A is the atomic mass number and K is the free parameter) is one of the important input parameters which affects the predicted cross sections [11,23,27,28]. In the optical model of a nucleus, the depth and shape of the nuclear potential undergo a slight change in the choice of optical model potential (OMP) parameters. The change in OMP parameters affects the scattering and reaction probabilities of the interacting particles

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and hence the corresponding reaction cross sections of various evaporation residues (ERs) of the reaction system. In certain experimental techniques based on offline measurements of excitation functions (EFs), the ICF fraction is extracted by analyzing the enhancement in the experimental cross sections, compared to the predicted theoretical cross sections of α-emitting channels. It is worth noting that PACE4 predicts cross sections only for CF channels and does not take ICF and pre-equilibrium (PE) channels into account. Experimental data already available in the literature for EFs of various ERs of the $^{12}C + ^{165}Ho$ system [29] have been analyzed [30] and compared with theoretical predictions made by the statistical model based computer code PACE4. In such studies, theoretical predictions made by a statistical model are indispensable factor in the estimation of the ICF fraction. Consequently, even a slight change in the theoretical cross sections for a reaction system, due to any variation in OMP parameters, may affect the strength of ICF considerably. As OMP parameters are not global or unique, several sets of OMP parameters have been reported for different ranges of mass number of targets and different ranges of energies [31]. Furthermore, some studies on mass dependence of model parameters are shown by the extended Hauser-Feshbach method of Matsuse [32], however these studies were not done to explore the effect of optical model parameters on the deduced ICF fraction for heavy ion reactions. In the literature, fractional ICF has been estimated utilizing theoretical predictions of cross sections obtained by PACE4, based on the default values of optical model parameters for almost all reaction systems [33–38], whereas, a single set of OMP parameters may not be adequate for the entire range of mass numbers [31] and various sets of OMP parameters may be required. A clear picture for the impact of different OMP parameters in HI induced reactions is yet to emerge.

As the fusion probability of nuclei is affected by the angle of projectile-target interaction [39], another factor that influences the ICF dynamics is the deformation of target nuclei. The ground state electric quadrupole deformation of target nuclei affects the shape of the nuclei and hence influences the interaction between projectile and target nuclei.

Thus, in order to explore the influence of change in OMP parameters and its impact on the estimation of strength of ICF for reaction systems involving different target and projectile combinations, an analysis has been made by the comparative study of experimental data available in the literature for EFs of systems $^{16}O + ^{181}Ta$ [40], $^{12}C + ^{165}Ho$, $^{14}N + ^{163}Dy$ [41], and $^{16}O + ^{74}Ge$ [42] with the theoretically predicted EFs, made in the framework of statistical model based computer code PACE4. The influence of deformation of target nuclei on the strength of ICF has also been investigated.

II. OPTICAL MODEL

According to the optical model, the target nucleus is replaced by an average complex potential $U(r)$, which acts upon the incident particle. The potential is complex and is known as the optical potential [31], generally represented as

$$U(r) = V_C - V f(x_0) + \left(\frac{h}{m_\pi c}\right)^2 V_{so}(\sigma . l)\frac{1}{r}\frac{d}{dr}f(x_{so})$$
$$- i\left[W f(x_W) - 4W_D \frac{d}{dx_D} f(x_D)\right],$$

where $V_C = Z_P Z_T e^2/r, r \geqslant R_C$ and $V_C = (Z_P Z_T e^2/2R_C)(3 - r^2/R_C{}^2), r \leqslant R_C$, as $R_C = r_C A^{1/3}$, and A is the mass number of the target nucleus. $f(x_i)$ are the Woods-Saxon form factors and $f(x_i) = (1 + e^{x_i})$, where $x_i = (r - r_i A^{1/3})/a_i$ and a_i is the diffuseness parameter. σ is the spin angular momentum operator. For reaction systems induced by heavy ions, the factor $A^{1/3}$ in the potential radius R_C is replaced by $(A_P{}^{1/3} + A_T{}^{1/3})$ where, A_P and A_T are respectively, the mass numbers of projectile and target nuclei. The four parameters (V, W, r_i, a_i), in general, are known as OMP parameters and are determined from scattering data fittings [31]. These parameters are a function of incident energy E, atomic number Z, and mass number A. The shape and depth of nuclear potentials may play a crucial role in the mechanism of nuclear reactions and influence the reaction cross-section calculations appreciably. In this complex potential, the real part V of the potential gives rise to pure scattering, while the imaginary part W of the potential is basically responsible for absorption producing inelastic scattering and reaction of interacting nuclei. Real and imaginary parts of the potential have their own individual parameters. Any variation in the potential depth parameters (V and W) affects the corresponding scattering and reaction cross sections. Overall, any variation in the OMP parameters may change the corresponding values of reaction cross sections for a particular interacting system.

Optical model calculations are used in the computer code PACE4 to compute the transmission coefficients for neutron (n), proton (p), and alpha particles (α), essential for the analysis of compound nucleus cross sections within the Hauser-Feshbach theory [43]. In order to calculate the transmission coefficients, PACE4 uses the complex optical potential and the corresponding phenomenological OMP parameter systematics described by Wilmore-Hodgson [44] for neutron, Becchetti-Greenlees [45] for proton, and Huizenga [46] and Satchler [47] for α particles as the default options. In the present work, the effect of the variation in OMP parameters has been studied extensively.

III. ANALYSIS, RESULTS, AND THEIR INTERPRETATIONS

In the present work, a comparative study of available experimental data of EFs for four systems, $^{16}O + ^{181}Ta$, $^{12}C + ^{165}Ho$, $^{14}N + ^{163}Dy$, and $^{16}O + ^{74}Ge$, with corresponding theoretical predicted EFs, made in the framework of the statistical model based computer code PACE4, has been done. As such the choice of OMP parameters is not global or unique, and different sets of OMP parameters may be used for different combinations of projectile-target nuclei, having different ranges of projectile energy and mass number of target nuclei. Hence, in order to observe the adequacy of choice of OMP parameters, theoretical predictions have been made with two different sets of OMP parameters in the present study. The first one, the systematic set of OMP parameters referred to as "Set 1," is incorporated in the computer code PACE4 as the default set of OMP parameters. For the said default set, the potential given below by Wilmore and Hodgson [44] is used as the neutron potential in Hauser-Feshbach calculations at low energies instead of the one given by Becchetti-Greenlees [45].

The neutron potential and other OMP parameters for Set 1 are (potentials are in MeV, radii in fermis)

$$V = 47.01 - 0.267E - 0.0018E^2,$$
$$r_0 = 1.322 - 7.6A \times 10^{-4} + 4A^2 \times 10^{-6} - 8A^3 \times 10^{-9},$$
$$a_0 = 0.66,$$
$$W_D = 9.52 - 0.053E,$$
$$r_D = 1.266 - 3.7A \times 10^{-4} + 2A^2 \times 10^{-6},$$
$$a_D = 0.48.$$

For the proton, the chosen default OMP parameters reproduce the data of EFs for reaction systems in the intermediate range of incident energy and medium weight nuclei, $30 \leqslant A \leqslant 100$. Set 1 of OMP parameters for the proton is [45]

$$V = 53.3 - 0.55E + 27(N - Z)/A + 0.4(Z/A^{1/3}),$$
$$r_0 = 1.25, a_0 = 0.65,$$
$$W_D = 13.5 \pm 2.0,$$
$$r_D = 1.25, a_D = 0.47,$$
$$V_{SO} = 7.5, r_{SO} = 1.064, a_{SO} = 0.78,$$
$$r_C = 1.25.$$

For α particles, fixed OMP parameters have been used in PACE4 [46]. The radius of the potential well is taken as constant for α particles in Set 1. OMP parameters for α particles are

$$V_0 = 50, \quad r_0 = 1.17A^{1/3} + 1.77, \quad a_0 = 0.576,$$
$$W_D = 45.7\exp(-x), \quad \text{where} \quad x = (r - 1.40A^{1/3})/a_D,$$
$$r_D = 1.17A^{1/3} + 1.77,$$
$$a_D = 0.576.$$

The second set of OMP parameters, referred to as "Set 2," inserted manually in a computer code with some variations, covers a higher energy range of incident energies of projectiles including a wider range of mass number, even at $A \geqslant 100$. Set 2 of OMP parameters for the proton is [48]

$$V = 49.9 - 0.22E + 26.4(N - Z)/A + 0.4(Z/A^{1/3}),$$
$$r_0 = 1.16, \quad a_0 = 0.75,$$
$$W = 1.2 + 0.09E,$$
$$W_D = 4.2 + 0.05E + 15.5(N - Z)/A,$$
$$r_W = r_D = 1.37,$$
$$a_W = a_D = 0.74 - 0.008E + 1.0(N - Z)/A,$$
$$V_{SO} = 6.04, \quad r_{SO} = 1.064, \quad a_{SO} = 0.78,$$
$$r_C = 1.25.$$

In Set 2, OMP parameters for the neutron are similar to that in Set 1. There are established results in the literature that a single set of OMP parameters for nucleons may not be adequate to predict the theoretical cross sections for the whole range of mass numbers [31]. Also, there are some global phenomenological OMP parameters for α particles given in the literature at energies well above the Coulomb barrier (CB), $E_{\text{lab}} \geqslant 10$ MeV/ nucleon [49,50]. It is worth pointing out that the calculated EFs for various CF residues are more or less same within statistical limits when either global OMP parameters or the default set of OMP parameters for α particles are used in PACE4. Moreover, α-particle scattering is not sensitive to the depth of the potential at small values of r [51]. Thus, in the present study, the effect of variation in OMP parameters has been studied in detail only for nucleons. HI studies with optical model potentials have parameter ambiguities [51]. The central depth of these potentials is not well determined as only the outer tail of potential is felt. Thus, in order to study the influence of change in potential, a variation in the value of V has also been studied.

A. *xn*/*pxn* channels

Experimental data available in the literature for xn/pxn channels of all the chosen systems, $^{16}O + ^{181}Ta$, $^{12}C + ^{165}Ho$, $^{14}N + ^{163}Dy$, and $^{16}O + ^{74}Ge$, have been compared with theoretical predictions of PACE4, utilizing both sets of OMP parameters. Level density $a = A/K$ MeV^{-1} is another important parameter of statistical code, where K is the free parameter. A detailed comparative study of all systems, chosen for the present study, has already been done with different values of K within permissible limits and has been published elsewhere [30,40]. In all the cases, the best fit of theoretical EFs to the experimental values is found to be with $K = 10$. Therefore, for the present calculations, K has been taken as 10 in all cases.

In Fig. 1, available experimental data of EFs for $3n$, $4n$, $5n$ channels of the $^{16}O + ^{181}Ta$ system have been plotted along with theoretically predicted EFs made by PACE4 using both sets of OMP parameters. It can be seen in Fig. 1 that theoretically predicted EFs for xn channels calculated by using Set 2 of OMP parameters satisfactorily reproduce the available experimental data in the low/medium incident energy range. An exception to this observation is the $3n$ channel for which the experimental data lie much higher as compared to PACE4 calculations in a higher incident energy range. The same may be attributed to pre-equilibrium emission which is not taken into account in the PACE4 calculations.

Further, available experimental data for xn channels of $^{12}C + ^{165}Ho$ and $^{14}N + ^{163}Dy$ systems have also been compared with theoretically predicted EFs by PACE4 using two sets of OMP parameters. Theoretically predicted EFs, calculated by PACE4 with Set 1, do not agree with experimental data of these two reaction systems; even Set 2 does not show good results. In order to get a better understanding, the impact of

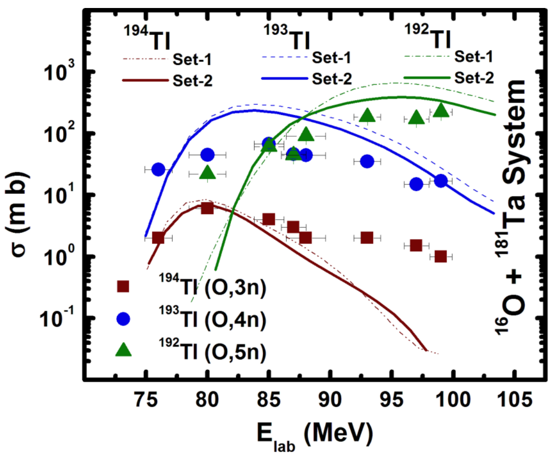

FIG. 1. Available experimental EFs for $3n$, $4n$, $5n$ channels of $^{16}O + ^{181}Ta$ system compared with PACE4 predictions using Set 1 and Set 2 of OMP parameters.

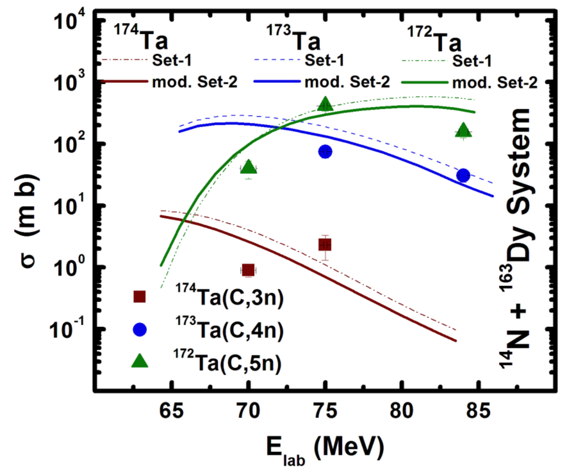

FIG. 3. Available experimental EFs for $3n$, $4n$, $5n$ channels of $^{14}N + ^{163}Dy$ system compared with PACE4 predictions using Set 1 and modified Set 2 (mod. Set-2) of OMP parameters.

more variation in the OMP parameters further needs to be investigated in the energy range 4–7 MeV/nucleon.

Hence, further modification has been done in Set 2, i.e., variations in the value of V for both neutron and proton potentials have been further investigated. A variation of 10% in the value of V is found to provide better fitting. Therefore, a comparative study of available experimental data of EFs for xn channels of systems $^{12}C + ^{165}Ho$ and $^{14}N + ^{163}Dy$ has been done with PACE4 predictions using Set 1 and Set 2 with 10% variation in the value of V (here onwards called modified Set 2 and shown as mod.Set-2 in figures).

It can be seen in Figs. 2 and 3 that experimental data of EFs for xn channels of systems $^{12}C + ^{165}Ho$ and $^{14}N + ^{163}Dy$ agree in good manner with PACE4 predicted EFs using modified Set 2. An exception to this observation is again the $3n$ channel for which the experimental data lie much higher as compared to PACE4 calculations in a higher incident energy range. The same may be attributed to pre-equilibrium emission which is not taken into account in PACE4 calculations.

Furthermore, a similar exercise has been done for pxn channels of systems $^{16}O + ^{181}Ta$ and $^{12}C + ^{165}Ho$. As can be seen from Figs. 4 and 5, experimental values are in good agreement with theoretical predictions made by PACE4, using Set 2 of OMP parameters for $^{16}O + ^{181}Ta$ and modified Set 2 for system $^{12}C + ^{165}Ho$ respectively for pxn channels.

For the fourth system $^{16}O + ^{74}Ge$, available experimental data of EFs for $4n$, $p2n$, $p3n$, $p4n$ channels have been compared with theoretically predicted EFs, made by PACE4, using Set 1 and Set 2 of OMP parameters and level density free parameter $K = 10$. It can be observed from Fig. 6 that the theoretical predictions of EFs, made by PACE4 with Set 1 of OMP parameters, provide better agreement with experimental data for the system $^{16}O + ^{74}Ge$, having a target of mass number 74 ($A < 100$), whereas, for the other chosen systems $^{16}O + ^{181}Ta$, $^{12}C + ^{165}Ho$, and $^{14}N + ^{163}Dy$, having $A > 100$,

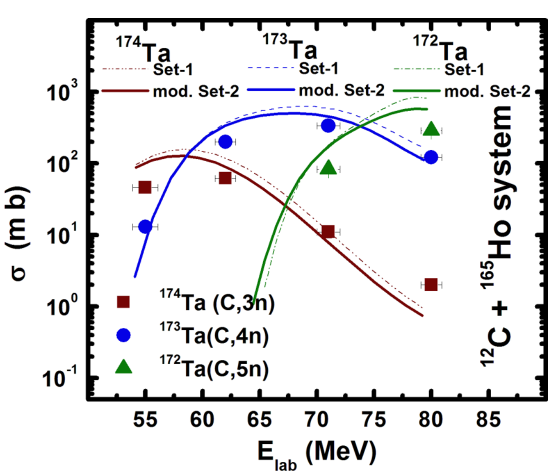

FIG. 2. Available experimental EFs for $3n$, $4n$, $5n$ channels of $^{12}C + ^{165}Ho$ system compared with PACE4 predictions using Set 1 and modified Set 2 (mod. Set-2) of OMP parameters.

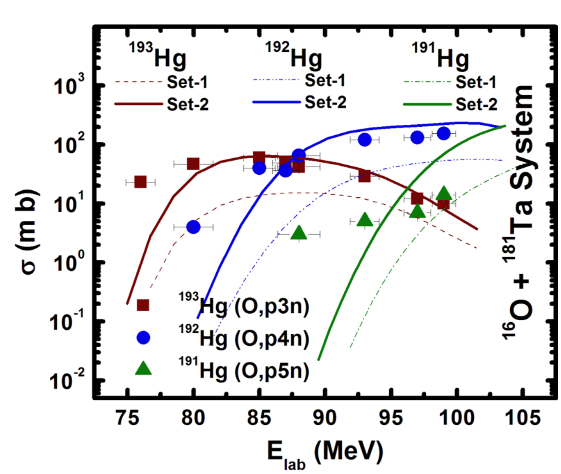

FIG. 4. Available experimental EFs for $p3n$, $p4n$, $p5n$ channels of $^{16}O + ^{181}Ta$ system compared with PACE4 predictions using Set 1 and Set 2 of OMP parameters.

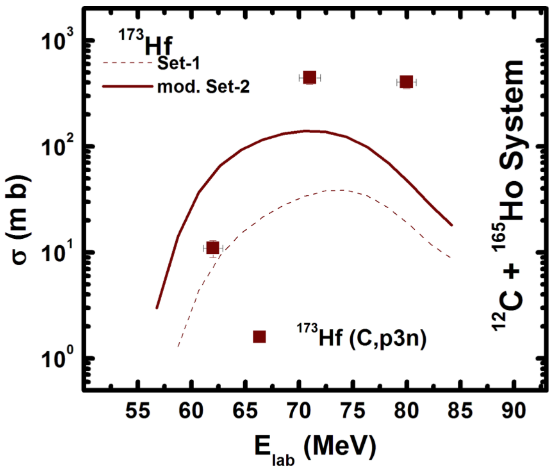

FIG. 5. Available experimental EFs for $p3n$ channel of $^{12}C + ^{165}Ho$ system compared with PACE4 predictions using Set 1 and modified Set 2 (mod. Set-2) of OMP parameters.

PACE4 predictions are in better agreement with experimental data of EFs for xn/pxn channels with Set 2 and modified Set 2.

B. Effect of OMP parameters on sum of theoretical EFs of α-emitting channels

Further, the sum of all the theoretical cross sections excluding the xn and pxn channels (σ_{TF}-$\Sigma\sigma_{xn+pxn}$), which is nothing but the sum of the theoretical cross sections of α-emitting channels, at different energies have been deduced and plotted for the systems $^{16}O + ^{181}Ta$, $^{12}C + ^{165}Ho$, and $^{14}N + ^{163}Dy$ for both the sets of OMP parameters (Set 2 for $^{16}O + ^{181}Ta$ and modified Set 2 for systems $^{12}C + ^{165}Ho$ and $^{14}N + ^{163}Dy$ along with Set 1) in Figs. 7(a)–7(c).

It can be seen that variations in the OMP parameters appreciably alter the sum of cross sections of α-emitting channels for systems $^{16}O + ^{181}Ta$, $^{12}C + ^{165}Ho$, and $^{14}N + ^{163}Dy$. The above mentioned changes in the sum of the cross sections of

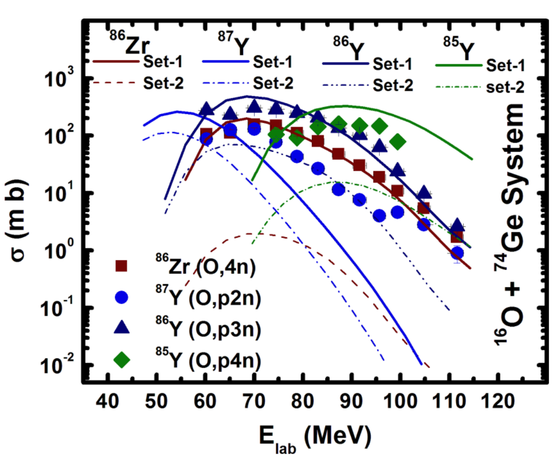

FIG. 6. Available experimental EFs for $4n$, $p2n$, $p3n$ and $p4n$ channels of $^{16}O + ^{74}Ge$ system compared with PACE4 predictions using Set 1 and Set 2 of OMP parameters.

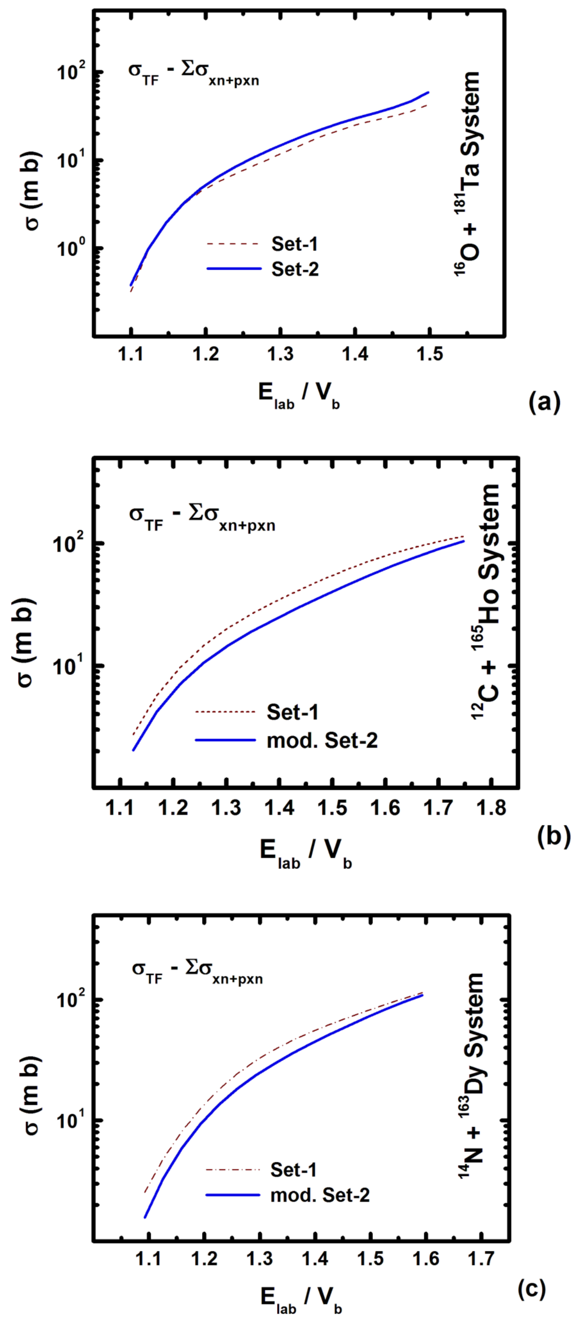

FIG. 7. Sum of theoretical PACE4 predicted EFs of all the channels, excluding $xn + pxn$ channels (σ_{TF}-$\Sigma\sigma_{xn+pxn}$) for $^{16}O + ^{181}Ta$, $^{12}C + ^{165}Ho$, and $^{14}N + ^{163}Dy$ systems using different sets of OMP parameters.

α-emitting channels have been tabulated at various normalized beam energy (E_{lab}/V_b) (see Table I).

In general, it is found that on changing the OMP parameters for nucleons the change in the sum of cross sections of α-emitting channels is approximately 10–30%.

The literature reports that in certain experimental techniques, based on activation analysis and offline measurements of EFs using characteristic γ-ray intensities, ICF fractions in the reaction system can be extracted by analyzing the

TABLE I. Sum of the cross sections of α-emitting channels with respect to E_{lab}/V_b.

	Sum of cross sections of α-emitting channels (mb)					
	System $^{16}O + ^{181}Ta$		System $^{12}C + ^{165}Ho$		System $^{14}N + ^{163}Dy$	
E_{lab}/V_b	Set 1	Set 2	Set 1	Modified Set 2	Set 1	Modified Set 2
1.11	0.619	0.681	1.832	1.351	0.605	0.714
1.17	2.962	3.015	7.616	5.439	10.995	8.389
1.24	7.064	7.972	12.661	9.421	18.972	14.296
1.28	10.082	12.819	17.044	12.695	26.042	18.809
1.32	15.210	18.496	23.521	16.396	37.704	28.529
1.38	21.882	27.077	31.487	22.964	54.834	45.570
1.42	26.731	32.187	40.178	28.723	62.222	51.541
1.48	37.665	51.000	48.056	34.828	76.956	65.809

enhancement in the experimental cross sections, compared to the predicted theoretical cross sections for α-emitting channels. Hence, any change in the theoretical cross section of α-emitting channels will change the overall enhancement in the fusion cross section of α-emitting channels, which will ultimately change the estimation of fractional ICF. So, it is clear from the above observations that, if there is redistribution in theoretical predictions of cross sections for various ERs due to alteration in OMP parameters, the calculated fractional ICF contribution will also be affected by the change in OMP parameters. Consequently, it can be inferred that correct estimation of strength of the ICF for a reaction system may depend on the proper choice of the OMP parameters. In further consequence, it may be surmised that systematics developed on the basis of calculated ICF fraction, in the study of ICF contribution for a reaction system, will also be affected and hence these systematics need to be studied.

C. ICF dependence on deformation parameter β_2

Electric quadrupole deformation is the deviation of the electric charge distribution of a nucleus from spherical symmetry. The ground state deformation of target nuclei affects the shape of the nuclei and hence influences the interaction between projectile and target nuclei. The shape of the axially symmetric deformed nucleus can be described by the ground state quadrupole deformation parameter β_2 in terms of intrinsic electric quadrupole moment Q_0 of the target nuclei as [52,53]

$$\beta_2 = \frac{Q_0\sqrt{5\pi}}{3ZR^2},$$

where R is nuclear charge radii and $R = R_0A^{1/3}$. Z is the atomic number of the target nucleus.

In HI induced nuclear reactions involving deformed targets, the fusion probability is affected by the angle of projectile-target interaction [39]. To understand the effect of deformation of the electric charge distribution of target nucleus on the ICF contribution for a given reaction system, a fraction of ICF (F_{ICF}) for the systems $^{16}O + ^{181}Ta$, $^{12}C + ^{165}Ho$, and $^{16}O + ^{74}Ge$ has been extracted by the enhancement in the experimental EFs in comparison to the PACE4 predicted theoretical EFs of α-emitting channels and plotted as a function of β_2 at constant relative velocity ($V_{rel} = 0.055c$).

It can be seen from Fig. 8 that, as the electric charge distribution of target nuclei departs from spherical symmetry, either as prolate or oblate deformation, the percentage of ICF increases with the increasing value of β_2. This result indicates that ICF for the reaction system is influenced by electric charge distribution of the target nuclei. In order to get a clear picture and further development of theoretical models, there is a need to explore the role of deformation on the incomplete fusion.

While performing these calculations, no correction could be done for missing ICF channels, but the correction for missing CF channels, due to various experimental limitations, has been incorporated using PACE4 predictions for those channels. Thus the quoted F_{ICF} (%) should be treated as a lower limit and formulation to calculate the F_{ICF} (%) has been given elsewhere [30].

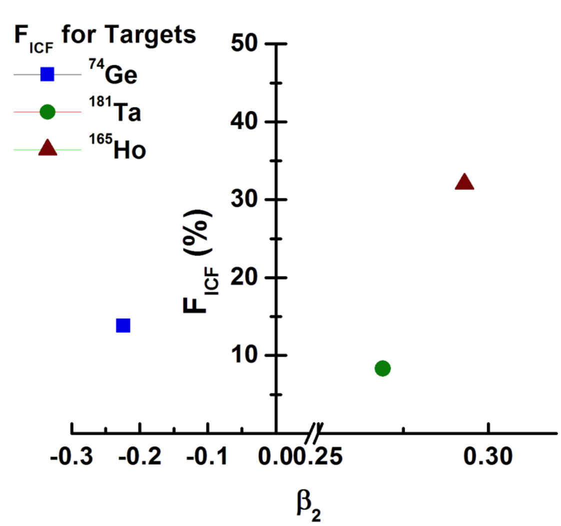

FIG. 8. Fractional ICF (F_{ICF}) as a function of target deformation parameter (β_2) for systems $^{16}O + ^{181}Ta$, $^{12}C + ^{165}Ho$, and $^{16}O + ^{74}Ge$ at constant relative velocity ($V_{rel} = 0.055\,c$).

IV. SUMMARY AND CONCLUSION

In the present work, an attempt has been made to analyze the influence of variation in OMP parameters over the estimation of ICF strength for a reaction system. As the choice of OMP parameters in the optical model potential is not global for all ranges of mass number and incident projectile energies, the effect of variation of OMP parameters on the estimation of fractional ICF has been studied for four reaction systems in the energy range 4–7 MeV/nucleon. A comparative study of available experimental data of EFs of xn/pxn channels for systems $^{16}O + ^{181}Ta$, $^{12}C + ^{165}Ho$, and $^{14}N + ^{163}Dy$, having targets with $A > 100$, provides fair agreement with one set of OMP parameters, whereas a comparison of available experimental data of EFs and theoretical predicted EFs for the system $^{16}O + ^{74}Ge$, having an $A < 100$ target nucleus, gives better agreement with another set of OMP parameters. Clearly, a single set of OMP parameters is not appropriate for all chosen reaction systems. An interesting conclusion that comes out from this analysis is that a different set of OMP parameters should be used for different ranges of mass number and incident energies, i.e., the choice of OMP parameters should be different for heavy and light target nuclei.

For the systems $^{16}O + ^{181}Ta$, $^{12}C + ^{165}Ho$, and $^{14}N + ^{163}Dy$, the sum of the theoretical cross sections of α-emitting channels, at different energies, have been examined with different sets of OMP parameters. It has been observed that the variation in the OMP parameters change the sum of the theoretical cross sections of α-emitting channels for chosen systems up to 10–30% approximately, clearly indicating that the variation in OMP parameters does affect the calculations of enhancement in the fusion cross section of α-emitting channels, consequently affecting the strength of ICF in the reaction system. Moreover, the fraction of ICF (F_{ICF}) for the chosen reaction systems when plotted as a function of β_2 at constant relative velocity ($V_{rel} = 0.055c$), increases as β_2 increases on either side of the intrinsic spherical symmetry.

Experimentally measured excitation functions for a large number of projectile and target combinations in different ranges of mass number and energy are required to portray a clear picture of the impact of choice of OMP parameters in HI induced nuclear reactions. A comprehensive analysis for various systems is also needed to elaborate the influence of deformation of target nuclei on the ICF of the reaction system.

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