Production of superheavy nuclei in the ^{48}Ca, ^{50}Ti, ^{51}V and ^{54}Cr induced reactions with the Skyrme energy-density functional approach

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Abstract

Within the framework of the dinuclear system model, the synthesis of superheavy nuclei in the ^{48}Ca, ^{50}Ti, ^{51}V and ^{54}Cr induced reactions have been systematically investigated. The nucleus-nucleus potential and potential energy surface is calculated by the well-known Skyrme energy-density functional theory with the parameters of SKM, SKM*, Ska, Z and SLy4, respectively, which correspond to the different nuclear equation of state. The available experimental data from Dubna, GSI, RIKEN and Berkeley are nicely reproduced. It is found that the incompressibility modulus influences the fusion-evaporation residue excitation functions and production cross sections of superheavy nuclei. The ^{48}Ca induced reactions, i.e., ^{48}Ca+^{248}Cm have the larger cross sections for synthesizing livermorium in comparison with the systems of ^{50}Ti+^{244}Pu and ^{54}Cr+^{238}U. The production cross sections of new elements with Z=119 and 120 in the reactions of ^{51}V+^{248}Cm and ^{54}Cr+^{243}Am/^{248}Cm are thoroughly analyzed and strongly depend on Skyrme parameters.

Full Text

Preamble

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It is found that the incompressibility modulus influences the fusion-evaporation residue excitation functions and production cross sections of superheavy nuclei. The 48Ca induced reactions, i.e., 48Ca+248Cm have larger cross sections for synthesizing livermorium in comparison with the systems of 50Ti+244Pu and 54Cr+238U. The production cross sections of new elements with Z=119 and 120 in the reactions of 51V+248Cm and 54Cr+243Am/248Cm are thoroughly analyzed and strongly depend on Skyrme parameters.

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I. INTRODUCTION

In past several decades, the synthesis of superheavy nuclei (SHN) has attracted much attention and significant progress has been obtained experimentally up to the element oganesson (Z=118). The competition between complete fusion and quasifission dynamics makes the formation of SHN a very complicated process. Multidimensional quantum tunneling, collective excitation, dynamical deformation, nucleon or cluster transfer, etc., influence the fusion dynamics required to form the compound nucleus by overcoming the Coulomb barrier [1]. Up to now, nuclear fusion reactions have been extensively investigated, particularly on topics such as weakly bound nuclei induced reactions [2], nuclear fusion at deep sub-barrier energies for astrophysical interests [3], and synthesis of superheavy nuclei (SHN) [4,5]. Roughly one third of nuclides on the nuclear chart have been synthesized in laboratories via fusion reactions [6]. The search for superheavy nuclei (SHN) in nature or synthesizing SHN in laboratories, particularly around the “island of stability” predicted theoretically, has been a topical issue in the past and present.

The cold-fusion reactions with 208Pb or 209Bi based targets were first proposed by Oganessian et al. [7]. The superheavy elements (SHEs) from Bh to Cn were successfully synthesized in cold-fusion reactions at GSI (Darmstadt, Germany) with the heavy-ion accelerator UNILAC and the SHIP separator [8,9]. Experiments on the synthesis of element Nh (Z=113) in the 70Zn+209Bi reaction have been performed successfully at RIKEN (Tokyo, Japan) [10]. The SHEs from Fl (Z=114) to Og (Z=118) have been synthesized at the Flerov Laboratory of Nuclear Reactions (FLNR) at Dubna (Russia) with the double-magic nuclide 48Ca bombarding actinide nuclei [11,12]. With new facilities being constructed worldwide such as RIBF (RIKEN, Japan) [13], SPIRAL2 (GANIL in Caen, France) [14], FRIB (MSU, USA) [15], and HIAF (IMP, China) [16], the synthesis of SHNs on the “island of stability” using neutron-rich radioactive beams induced fusion reactions or via multinucleon transfer (MNT) reactions might become possible experimentally.

Accurate estimation of SHN production cross sections is particularly important for experimental synthesis, i.e., for determining the optimal combination of reaction system, beam energy, evaporation channel, etc. Fusion dynamics is strongly governed by the nucleus-nucleus (NN) potential. The most significant quantity is the Coulomb barrier, which is determined by the attractive nuclear and repulsive Coulomb potentials. Usually, the NN potential is used to calculate the fusion cross-section with a quantum penetration or coupled-channel approach. The fusion probability rapidly decreases with reducing incident energy below the Coulomb barrier. An empirical formula was proposed by Bass for estimating the Coulomb barrier and fusion cross section [17]. In light and medium reaction systems, the compound nucleus is formed after overcoming the Coulomb barrier. However, the quasifission mechanism may take place in heavy projectile-target combinations, in which the disintegration of the colliding system after a few nucleon transfers hinders compound nucleus formation. Neck dynamics, shape evolution, collective excitation, and nucleon transfer influence the NN potential. It is known that the NN potential in fusion reactions is associated with shape evolution and beam energy in dynamical models, e.g., time-dependent Hartree-Fock (TDHF) approach [18] and quantum molecular dynamics (QMD) model [19]. There are mainly two sorts of NN potential: phenomenological potentials such as the Woods-Saxon potential [20,21], proximity potential [22], potentials (Yukawa-plus-exponential, DDM3Y, Migdal) via the double-folding method [23–25], and the adiabatic potential [26]. It is also possible to construct the NN potential within the energy-density functional approach based on the effective nucleon-nucleon interaction, i.e., the Skyrme force [27,28], the finite-range Gogny interaction [29], etc. The advantage of the energy-density functional approach is that it enables a unified description of nuclear structure, nuclear dynamics, and nuclear matter based on the effective nucleon-nucleon interaction.

In this work, the NN potential is calculated within the Skyrme energy-density functional. The potential energy surface is obtained with this approach and the production of SHN is discussed by implementing it into the dinuclear system (DNS) model. The article is organized as follows. In Section 2 we give a brief description of Skyrme energy-density functional theory and the potential energy surface in the DNS model. The fusion-evaporation excitation functions for SHN production in the 48Ca, 50Ti, 51V and 54Cr induced reactions on actinide nuclei are systematically investigated in Section 3. A summary and perspective on the NN potential are presented in Section 4.

II. BRIEF DESCRIPTION OF THE MODEL

The nucleus-nucleus potential is a basic quantity for describing nuclear dynamics in low-energy heavy-ion collisions. The interaction potential in binary collisions depends on the collision orientation and is composed of nuclear and Coulomb contributions as follows [30,31]:

$$V(R, \alpha_P, \alpha_T, J) = V_{\text{nucl}}(R, \alpha_P, \alpha_T) + V_{\text{Coul}}(R, \alpha_P, \alpha_T) + \frac{\hbar^2 J(J+1)}{2\mu_{\text{rel}} R^2}$$

Here the Coulomb potential is calculated by the well-known Wong's formula [20]. The α_i denotes the symbols R_i, θ_i, β_i with $i = P, T$ being the projectile or target nucleus. The R_i, θ_i, β_i represent the nuclear radii, quadrupole deformations, and polar angles between the beam direction and the symmetry axes of deformed nuclei, respectively. The R is the center-of-mass distance of projectile and target nuclides. Shown in Fig. 1 [Figure 1: see original paper] is the definition of the quantities $R_1, R_2, \theta_1, \theta_2$ and the integration variables r, θ. The deformation effect is included in the nuclear and Coulomb potentials, which results in the orientation dependence of the Coulomb barrier and influences the quasifission dynamics in massive fusion reactions. The multiple integral with the energy-density functional by the Skyrme force is performed in the spherical coordinate system (r, θ, ϕ).

The nuclear potential is calculated by the Skyrme energy-density functional as [32,33]:

$$V_{\text{nucl}}(R, \{\alpha\}_P, \{\alpha\}_T) = E_{\text{sys}}(R, \{\alpha\}_P, \{\alpha\}_T) - E_P(\{\alpha\}_P) - E_T(\{\alpha\}_T)$$

The E_{sys}, E_P and E_T are the binding energies contributed from the nucleon-nucleon force of the colliding system, projectile, and target nuclei by the relation $E = \int\int\int \varepsilon[\rho_p(r), \rho_n(r)] r^2 \sin(\theta) dr d\theta d\phi$, respectively. The energy-density functional $\varepsilon[\rho_p(r), \rho_n(r)]$ is derived from the Skyrme force as (see details in Appendix):

$$\hat{V}_{\text{eff}}(r_1, r_2) = t_0(1+x_0\hat{P}_\sigma)\delta(r_1-r_2) + \frac{1}{2}t_1(1+x_1\hat{P}_\sigma)[\delta(r_1-r_2)k^2 + k'^2\delta(r_1-r_2)] + t_2(1+x_2\hat{P}_\sigma)k' \cdot \delta(r_1-r_2)k + \frac{1}{6}t_3(1+$$

with the spin-exchange operator $\hat{P}_\sigma = \frac{1}{2}(1 + \hat{\sigma}_1 \cdot \hat{\sigma}_2)$. The zero-range effective forces between nucleons in the nuclear environment provide the energy-density functional and are available for the ground-state properties of finite nuclei and nuclear matter at saturation density [34].

The energies of the colliding system, projectile, and target nuclei are calculated by:

$$E_{\mathrm{sys}}(R,\{\alpha\}_P,\{\alpha\}_T)=\int\varepsilon[\rho_{1p}(r)+\rho_{2p}(R-r),\rho_{1n}(r)+\rho_{2n}(R-r)]dr$$

$$E_P(\{\alpha\}_P)=\int\varepsilon[\rho_{1p}(r),\rho_{1n}(r)]dr$$

$$E_T(\{\alpha\}_T)=\int\varepsilon[\rho_{2p}(R-r),\rho_{2n}(R-r)]dr$$

respectively. The density profiles of proton and neutron distributions for projectile and target nuclides are taken to be frozen in the Woods-Saxon form as:

$$\rho_{1i}(r)=\frac{\rho_{0i}}{1+\exp[(r-R_P)/a_i]},\quad i=\{n,p\}$$

with the diffuseness coefficients a_i being values of 0.55-0.65 fm. The projectile radii with quadrupole deformation are given by $R_P=R_{0P}[1+\beta_2 Y_{20}(\theta)]$ with $R_{0P}=1.28A^{1/3}-0.76+0.8A^{-1/3}$. Similarly, the neutron and proton density distributions of the target nucleus are obtained.

With the help of the well-known extended Thomas-Fermi (ETF) approximation, the kinetic energy term is obtained up to second order extension. The energy density is expressed as [28]:

$$\varepsilon[\rho_p(r),\rho_n(r)]=\frac{\hbar^2}{2m}(\tau_p(r)+\tau_n(r))+\nu_{\mathrm{sk}}(r)$$

with the kinetic energy term:

$$\tau_i(r)=\frac{3}{5}(3\pi^2)^{2/3}\rho_i^{5/3}+\frac{1}{36}\frac{(\nabla\rho_i)^2}{\rho_i}+\frac{1}{6}\Delta\rho_i$$

The potential part in the energy-density functional is given by:

$$\nu_{\mathrm{sk}}(r)=\frac{t_0}{2}\left[(1+\frac{x_0}{2})\rho^2-(x_0+\frac{1}{2})(\rho_n^2+\rho_p^2)\right]+\frac{t_3}{12}\left[(1+\frac{x_3}{2})\rho^{\alpha+2}-(x_3+\frac{1}{2})\rho^{\alpha}(\rho_n^2+\rho_p^2)\right]+\frac{1}{4}[t_1(1+\frac{x_1}{2})+t_2(1+$$

The parameters $t_0,t_1,t_2,t_3,x_0,x_1,x_2,x_3$, the density-dependent stiffness α and the spin-orbit strength W_0 are listed in Table 1 . Six sets of Skyrme parameters SkM, SkM*, Ska, Z and SLy4 are used in the calculation. The binding energies, root-mean-square radii of finite nuclei around magic numbers, and nuclear matter properties at saturation density are self-consistently described with these forces.

The nucleus-nucleus (NN) potential is of importance in describing nuclear dynamics, i.e., α decay, low-energy heavy-ion collisions, quasifission process, fusion-evaporation reactions, etc. [39,40]. Consequently, quasifission yields, fusion-fission products, fusion cross sections, isotopic distributions, and angular and kinetic energy spectra in deep inelastic collisions or multinucleon transfer reactions are influenced by the NN potential. Deformation, collective excitation, shape evolution, and initial orientation also influence the nucleus-nucleus potential [41–43].

In realistic nuclear reactions, the density profile varies with the evolution time of the colliding system and leads to a complicated NN potential. Two typical approximations are usually used in reaction models: sudden approximation and adiabatic approach. In our calculation, the sudden approximation with frozen nuclear density is used in the potential energy surface and the estimation of SHN production. As a typical reaction system, the 48Ca induced fusion reactions on actinide nuclides were chosen for successfully synthesizing SHN with Z=112-118 at Dubna. We select the Skyrme forces SKM, SKM*, Ska, Z and SLy4 corresponding to different incompressibility moduli of nuclear matter at normal density. Shown in Fig. 1 [Figure 1: see original paper] is the comparison of NN potentials in collisions of 48Ca+243Am and 48Ca+248Cm, respectively. The difference in NN potentials from the Skyrme forces is obvious and arises from different compression moduli of nuclear matter. It is assumed that the DNS is formed at the bottom of the potential pocket. A broader and deeper pocket is favorable for compound nucleus formation against quasifission reactions.

The formation of superheavy nuclei in massive fusion reactions is complicated and associated with nucleon transfer, shape evolution, neck formation, relative motion energy, and angular momentum dissipation. In the dinuclear system model, the density profiles of colliding nuclei are taken to be frozen and neck dynamics is not taken into account. Nucleon transfer is coupled to the relative degrees of freedom via a set of master equations by the potential energy surface (PES). The PES is given by:

$$U(R,\{\alpha\}) = Q_{gg}(Z_1,N_1) + V(R,\{\alpha\})$$

with

$$Q_{gg}(Z_1,N_1) = B(Z_1,N_1) + B(Z_2,N_2) - B(Z_{\text{com}},N_{\text{com}})$$

The $B(Z_i,N_i)$ $(i=1,2)$ and $B(Z_{\text{com}},N_{\text{com}})$ are the negative binding energies of the fragment (Z_i,N_i) and the compound nucleus $(Z_{\text{com}},N_{\text{com}})$, respectively. The symbol $\{\alpha\}$ denotes the quantities $Z_1,N_1,\theta_1,\theta_2,\beta_1,\beta_2$. The β_i represent the quadrupole deformations of two DNS fragments at ground state. The θ_i denote the angles between collision orientations and the symmetry axes of deformed nuclei. The nucleus-nucleus potential between fragments (Z_1,N_1) and (Z_2,N_2) includes nuclear and Coulomb interactions.

In the calculation, the distance R between the centers of the two fragments is chosen to be the value at the touching configuration, in which the DNS is assumed to be formed. Shown in Fig. 2 [Figure 2: see original paper] is the driving potential as a function of mass asymmetry ($\eta = (A_1 - A_2)/A_{\mathrm{CN}}$) in the reactions of 48Ca + 243Am and 48Ca + 248Cm, respectively. The Businaro-Gallone (B.G.) point is marked at the maximal position of the driving potential. The difference in driving potentials with the Skyrme forces SKM, SKM*, Ska, Z and SLy4 arises from the NN potential. The fusion probability is related to the inner fusion barrier, which is defined as the difference between the driving potential at the B.G. point and the one at the incident position. A low inner fusion barrier is favorable for compound nucleus formation.

The DNS model has been applied to quasifission and fusion dynamics, multinucleon transfer reactions, and deep inelastic collisions, in which the dissipation of relative motion and rotation of the colliding system into internal degrees of freedom is assumed at the touching configuration. The DNS system evolves along two main degrees of freedom to form a compound nucleus: radial motion via the decay of DNS and nucleon transfer via the mass asymmetry $\eta = (A_1 - A_2)/(A_1 + A_2)$ or charge asymmetry $\eta_Z = (Z_1 - Z_2)/(Z_1 + Z_2)$ [44,45]. In accordance with the temporal sequence, the system undergoes capture by overcoming the Coulomb barrier, competition between quasifission and complete fusion via cascade nucleon transfer, and formation of a cold residue nuclide by evaporating γ-rays, neutrons, light charged particles, and binary fission. The production cross section of the superheavy residue is estimated by the sum of partial waves with angular momentum J at incident center-of-mass energy $E_{\mathrm{c.m.}}$ as:

$$\sigma_{\mathrm{ER}}(E_{\mathrm{c.m.}}) = \frac{\pi\hbar^2}{2\mu E_{\mathrm{c.m.}}} \sum_{J=0}^{J_{\max}} (2J+1) T(E_{\mathrm{c.m.}}, J) P_{\mathrm{CN}}(E_{\mathrm{c.m.}}, J) W_{\mathrm{sur}}(E_{\mathrm{c.m.}}, J)$$

Here, $T(E_{\mathrm{c.m.}}, J)$ is the penetration probability given by the Hill-Wheeler formula and a Gaussian-type barrier distribution [31]. The distribution function is taken as the Gaussian form $f(B) = \frac{N}{\sqrt{\pi}\Delta} \exp[-((B - B_m)/\Delta)^2]$, with the normalization constant satisfying the unity relation $\int f(B)dB = 1$. The quantities B_m and Δ are evaluated by $B_m = (B_C + B_S)/2$ and $\Delta = (B_C - B_S)/2$, respectively. The B_C and B_S are the Coulomb barrier at waist-to-waist orientation and the minimum barrier by varying the quadrupole deformation of the colliding partners. The fusion probability P_{CN} is described by the DNS model and takes into account the competition between quasifission and fission of the heavy fragment [45], in which nucleon transfer is described by solving a set of microscopically derived master equations distinguishing protons and neutrons. The survival probability W_{sur} is calculated with the Weisskopf statistical theory [46], in which the decay of the compound nucleus formed in the fusion reaction is cooled by evaporating γ rays and light particles including neutrons, protons, and α particles in competition with binary fission.

III. RESULTS AND DISCUSSION

The nucleus-nucleus potential is of significance in low-energy heavy-ion collisions, i.e., the fusion cross section, quasifission dynamics, fusion-fission reaction, and fusion-evaporation for synthesizing heavy or superheavy nuclei. A repulsive core with incompressibility modulus of $K = 228$ MeV is introduced into the Michigan-3-Yukawa-Reid effective potential for describing fusion cross sections at energies far below the Coulomb barrier in the reaction of 64Ni + 64Ni [47]. The energy density functional method paves a bridge between the nucleon-nucleon effective force and nuclear matter equation of state, i.e., the Skyrme effective interaction, relativistic invariant theory based on the meson-exchange concept, chiral effective theory, etc. The effective Skyrme force is expected to provide a unified description of nuclear ground-state properties, nuclear reactions, and nuclear matter. The potential energy surface influences nuclear dynamics in fusion-evaporation and fusion-fission reactions. Consequently, fusion cross sections are correlated with the incompressibility modulus and effective nucleon-nucleon interaction.

Shown in Fig. 3 [Figure 3: see original paper] is the fusion-evaporation residue excitation functions in the reaction of 48Ca+243Am for producing moscovium with the Skyrme parameters SKM, SKM*, Ska, Z, SLy4 and available data from Dubna [48–54]. It is obvious that the maximal cross section is 20 pb at the excitation of 35 MeV in the 3n evaporation channel from experimental measurements. The production cross sections of SHNs with different Skyrme forces are related to the density in the overlap region and nuclear matter properties. Overall, the fusion-evaporation excitation functions with parameter SLy4 (*$K = 230$ *MeV) are consistent with available data. The uncertainties of the Skyrme forces on SHN production cross sections are collected and compared in Fig. 3(f). It is demonstrated that the maximal cross sections in the 2n-5n evaporation channels are similar for different Skyrme forces. The fusion-evaporation residue excitation functions with Skyrme parameters SKM, SKM*, Ska, Z and SLy4 in the reaction of 48Ca+248Cm are calculated and compared with available data from Dubna [55–59], GSI [60] and RIKEN [61]. It is obvious that the maximal cross section in the 4n channel is 5 pb at $E^*_{\mathrm{CN}} = 40$ MeV. The uncertainties of production cross sections are huge for different Skyrme forces owing to the larger overlap density in comparison with the reaction of 48Ca+243Am. The lower cross section for producing livermorium than for moscovium is mainly caused by the reduction of the fission barrier of the compound nucleus, which manifests the dominance of shell effects in SHN formation.

Recently, new superheavy elements beyond oganesson have attracted attention in experiments and theories. The 48Ca induced reactions face some obstacles due to target material management. The combination of 50Ti, 51V and 54Cr on actinide nuclei paves the way for synthesizing new elements 119 and 120. In comparison with 48Ca induced reactions, the production cross section of SHN is usually reduced by the high inner fusion barrier and Q-value in 50Ti, 51V and 54Cr induced reactions. Shown in Fig. 5 [Figure 5: see original paper] are the fusion-evaporation residue excitation functions in the reaction of 50Ti+238U. It is obvious that the 5n channel has cross sections below 0.01 pb and the distribution structure differs with Skyrme parameters SKM, SKM*, SKa, Z and SLy4. Roughly, the 2n-4n channels with maximal cross sections of 0.1-1 pb are obtained with Skyrme forces SKM, SKM*, SKa and Z. However, parameter SLy4 predicts larger cross sections for flerovium production. The difference in Skyrme forces for calculating fusion-evaporation excitation functions mainly arises from the NN potential and potential pocket (width and height). A narrower potential pocket enables lower fusion probability and results in reduction of SHN cross sections. The attempt of 50Ti beams on 244Pu was performed at Berkeley [62]. Comparison of calculated results and experimental data is shown in Fig. 6 [Figure 6: see original paper]. Basically, the 4n channel is available for producing livermorium and consistent with data using Skyrme forces SKM, SKM* and Z. Parameter Ska predicts unexpectedly very low cross sections. The uncertainties of SHN production cross sections are huge with magnitudes of 2-5 orders, particularly with decreasing excitation energy.

The 51V induced reactions have attracted much attention for synthesizing new SHN beyond 48Ca. More mass-asymmetric systems are favorable for enhancing fusion probability. As a test for the new reaction mechanism, the system of 51V + 243Am is feasible for producing oganesson in experiments. The fusion-evaporation excitation functions with Skyrme parameters SKM, SKM*, SKa, Z and SLy4 are calculated as shown in Fig. 7 [Figure 7: see original paper]. Cross sections in 2-4n channels are possible for measurement in experiments. However, for synthesizing new element 119, production cross sections below 1 fb are found with Skyrme forces SKM, SKM*, SKa and Z as shown in Fig. 8 [Figure 8: see original paper].

In recent years, high-intensity 54Cr beams have been provided at accelerators worldwide, i.e., the SHE factory in Dubna, SHE special accelerator (CAFe II) and gas-filled recoil separator spectrometer (SHANS2). Shown in Fig. 9 [Figure 9: see original paper] is the fusion-evaporation excitation function calculated by the DNS model with the Skyrme energy density functional using SKM, SKM*, SKa, Z and SLy4 in the reaction of 54Cr+238U, compared with Dubna data [63]. The production cross section of 288Lv in the 4n channel is nicely reproduced with Skyrme forces SKM, SKM* and Z. The 4n channel at excitation energy of 41 MeV is the optimal way for synthesizing SHN, and the excitation energy increases compared to 38 MeV in the reaction of 48Ca+248Cm for producing livermorium. The larger binding energy of double-magic nucleus enlarges the Q-value and is favorable for SHN formation due to survival probability. Accurate estimation of fusion-evaporation excitation functions induced by 54Cr on actinide nuclei is helpful for synthesizing new elements in laboratories. We calculated oganesson production in the 54Cr+244Pu reaction as shown in Fig. 10 [Figure 10: see original paper]. The 2-4n evaporation channels are dominant for SHN formation with cross sections within the region of 10^{-5} pb. Measurements on this system are expected for checking predictions and extending the synthesis of new SHN with 54Cr beams. New element synthesis has attracted much attention in experiments, e.g., 58Fe+244Pu [64], 64Ni+238U, 54Cr+248Cm and 50Ti+249Cf [65]. The fusion-evaporation excitation functions for synthesizing new SHEs with Z=119 and Z=120 in reactions of 54Cr+243Am and 54Cr+248Cm are calculated as shown in Fig. 11 [Figure 11: see original paper] and Fig. 12 [Figure 12: see original paper], respectively. It is obvious that production cross sections for elements 119 and 120 are below 1 fb with predictions from Skyrme forces SKM, SKM*, SKa and Z, except for SLy4. The depth and width of the potential pocket of NN potential are correlated with nuclear matter properties of EOS and the diffusion magnitude of proton and neutron density profiles. It has been shown that mass tables of nuclides also influence the PES and separation energies, consequently affecting SHN production [66].

IV. CONCLUSIONS

In summary, the nucleus-nucleus potential is calculated with the Skyrme energy density functional, which is associated with the incompressibility modulus of nuclear matter using Skyrme forces SKM, SKM*, Ska, Z and SLy4. The fusion-evaporation excitation functions in 48Ca, 50Ti, 51V and 54Cr induced reactions on actinide nuclei are systematically investigated for producing SHN within the DNS model. It is demonstrated that the discrepancy in fusion-evaporation cross sections with different Skyrme forces comes from the stiffness of nuclear incompressibility modulus and from the inner fusion barrier. Available data from Dubna, GSI and RIKEN and fusion-evaporation residue excitation functions in reactions of 48Ca+243Am and 48Ca+248Cm are nicely reproduced by SKM, SKM* and Z.* The predicted cross sections for new SHE production with Z=119 and 120 are 1 fb in the 54Cr+243Am reaction and below 0.1 fb in collisions of 54Cr+248Cm, respectively.

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