Study of the synthesis of superheavy nuclei in hot fusion reactions

Nan Wang[1], En-Guang Zhao[2,3], Werner Scheid[4] and Shan-Gui Zhou[2,3]

[1]College of Physics, Shenzhen University, Shenzhen 518060, China

[2]State Key Laboratory of Theoretical Physics, Institute of Theoretical Physics, Chinese Academy of Sciences, Beijing 100190, China

[3]Center of Theoretical Nuclear Physics, National Laboratory of Heavy Ion Accelerator, Lanzhou 730000, China

[4]School of Physics, Peking University, Beijing 100871, China

[4]Institute of Theoretical Physics of Justus-Liebig-University, D-35392 Giessen, Germany

Abstract

The dynamical deformations of two fragments developed during the reaction process in the heavy-ion reactions leading to super-heavy nuclei(SHN) are investigated theoretically. A di-nuclear system with a dynamical potential energy surface (DNS-DyPES) model is developed. In the model, the maximal dynamical deformations for the nuclei are determined by minimizing the total "intrinsic" energy which includes the nuclear potential and Coulomb potential between two nuclei and the excitation energies due to nuclear distortions. And the developed DNS-DyPES model is used to study the hot fusion reactions for synthesizing superheavy nuclei (SHN) with charge numbers Z from 112 to 120. For reactions leading to SHN with Z from 112 to 118, the calculated evaporation residue cross sections are in good agreement with available data. In these reactions, the projectile is ^{48}Ca and targets are ^{238}U, ^{237}Np, ^{242}Pu, ^{243}Am, ^{248}Cm, ^{249}Bk, and ^{249}Cf, respectively. For SHN with Z = 113, 115, and 118, the maximal evaporation residue cross section is found in the 3n evaporation-residue channel, and for those with Z = 114, 116, and 117, the 4n channel is more favorable. In the reaction ^{50}Ti+^{249}Bk$\rightarrow^{299-x}$119 + xn, the maximal evaporation-residue (ER) cross section is found to be about 0.11 pb for the 4n-emission channel. For projectile-target combinations producing SHN with Z = 120, the ER cross section increases as the mass asymmetry in the incident channel increases. The maximal ER cross sections for ^{58}Fe+^{244}Pu and ^{54}Cr+^{248}Cm are relatively small (less than 0.01 pb) and those for ^{50}Ti+^{249}Cf and ^{50}Ti+^{251}Cf are about 0.05 and 0.25 pb, respectively.