Dynamics of dinuclear system formation and its decay in heavy ion collisions

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In the study of processes in the heavy ion collisions at low energies, various phenomena are observed due to the different peculiarities of the dinuclear system formation. Deeply inelastic collisions have been extensively studied over a wide range of energies and masses [1]. The set of experimental results in the synthesis of superheavy elements stimulated the great effort to the experimental and theoretical investigations of the fusion-fission processes with massive nuclei. The observed very small cross sections σ_{ER} of the evaporation residues about 1 pb and lower values [2] may be explained by the strong fusion hindrance and/or instability of the heated and rotating compound nucleus.

The study of the reaction mechanism is connected with the correct theoretical and experimental estimations of each physical quantity of formula (1):

$$\sigma_{ER}(E_{c.m.}) = \Sigma_{\ell=0}^{\ell_{cap}} \sigma_{cap}(E_{c.m.}, \ell) P_{CN}(E_{c.m.}, \ell) W_{surv}(E^*, \ell), \quad (1)$$

where $E^* = E_{c.m.} + Q_{gg}$; P_{CN} is a probability of complete fusion which takes into account hindrance caused by quasifission process and $W_{surv}(E^*, \ell)$ is a survival probability of the heated and rotating nucleus again fission. Fortunately σ_{ER} is measured with enough good accuracy and without additional assumption about the origination of the evaporation residues. We have problems at theoretical and experimental estimations of the capture and fusion cross sections: $\sigma_{cap} = \Sigma_{\ell=0}^{\ell_{cap}} \sigma_{cap}(\ell)$, $\sigma_{fus} = \Sigma_{\ell=0}^{\ell_{cap}} \sigma_{cap}(\ell) P_{CN}(\ell)$. The mass and angular distributions of the capture reaction products can overlap with the deeply inelastic collisions. More serious consequences are connected with the mixing the mass and angular distributions of the fusion-fission and quasifission products. Quasifission process was proposed as a hindrance to complete fusion in reactions with massive nuclei [3]. In contrast to fusion-fission reactions in a quasifission process the binary products are formed at decay of dinuclear system which had not reached the compound nucleus stage during its evolution.

The dominance of quasifission product yields in the wide range of the mass and charge distributions causes difficulties in the unambiguous estimation of the complete fusion cross sections. The knowledge about fusion excitation function allows us to establish favorable reaction and optimal beam energy at synthesis of the superheavy elements or new isotopes of atomic nuclei far from the island of stability.

The dinuclear system model allows us to study the behavior of the dinuclear system which plays important role in formation of reaction products. It allows us to analyze the experimental data and their interpretations by comparison of the partial capture, fusion and evaporation residues cross sections measured for different reactions leading to the same compound nucleus. The comparison of theoretical and experimental values of the mass and angular distributions of the reaction products gives us detail information about reaction mechanism forming the observed yields. The reactions leading to synthesize of new superheavy element Z=120 will be discussed.

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