Dynamics of Heavy-Ion Fusion and Synthesis of Superheavy Elements

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Synthesis of superheavy elements becomes more and more difficult experimentally as an atomic number of the element becomes larger. The residue cross sections become smaller and smaller, and now less than 1.0 pb. Therefore, a reliable theoretical prediction is strongly desired. The smallness of the cross sections stems from the two factors ; the fusion and the survival probabilities. The latter should be extremely small because the fissility parameters are close to 1, and thus there is no macroscopic fission barrier which sustains the nuclei against fission, that is, only the shell correction energy can give rise to their stability. In brief, the superheavy nuclei are inherently fragile. The fusion probability has been experimentally known to be very small in massive systems. The fusion is even hindered, which is shown typically by the necessity of so-called "extra-push energy". Theoretically, its physical mechanism is not well understood, but is clarified recently. Even, analytic formulae for the hindered probability as well as for the extra energy are given. [1] Furthermore, realistic calculations of the fusion probability for the superheavy elements are made to predict residue cross sections. [2]

Now, we are trying to reduce ambiguities in the realistic calculations and to suggest promising incident channels. incident energies etc., and finally to provide reliable predictions for excitation functions for the cold as well as hot fusion paths. In the course of analyses of the measured fusion excitation function and the measured $1n$ residue cross section in ^{58}Fe+^{208}Pb system, we have found an incompatibility between two. There might be a problem in the experiments, say, a contamination of quasi-fission process, but at the same time,we have pointed out another possibility to explain a virtual inconsistency between two data. That is, so-called shell damping energy in the superheavy nuclei could be different from the value known in lighter systems. Since the shell correction energy guaranttees the stability, how it recovers itself as the system cools down, which is reported in XIII Nuclear Physics Workshop - Marie and Pierre Curie- in Poland, September 2006. [3]

In order to upgrade the reliability of the theoretical predictions, we have developed a new computer code for the statistical decay KEWPIE II. One of the collaborators, Anthony Marchix is now preparing Ph D thesis to be submitted to Univ. of Caen, September 2007.

A new method has also been developed for solving Langevin equation with a memory kernel. An analytical solution and results by a new numerical argorithm are compared to establish the method. [4]

Furthermore, we have started to investigate the role of the neck degree of freedom in the fusion process. In other words, how the neck of the di-nucleus system is filled in to form a mono-nucleus, which is expected to provide a deeper understanding of fusion of massive systems, i.e., of the synthesis of the superheavy elements.

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