Giant quasi-atoms and superheavy nuclei obtained in collisions of transactinides

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For near-barrier collisions of heavy ions it is very important to perform a combined (unified) analysis of all strongly coupled channels: deep-inelastic scattering, quasi-fission, fusion and regular fission. A unified potential energy surface is derived determining the evolution of the nuclear system in all the channels and a unified set of dynamic Langevin type equations is proposed for the simultaneous description of deep-inelastic and fusion-fission processes. For the first time, the whole evolution of the heavy nuclear system can be traced starting from the approaching stage and ending in deep-inelastic, quasi-fission, and/or fusion-fission channels.

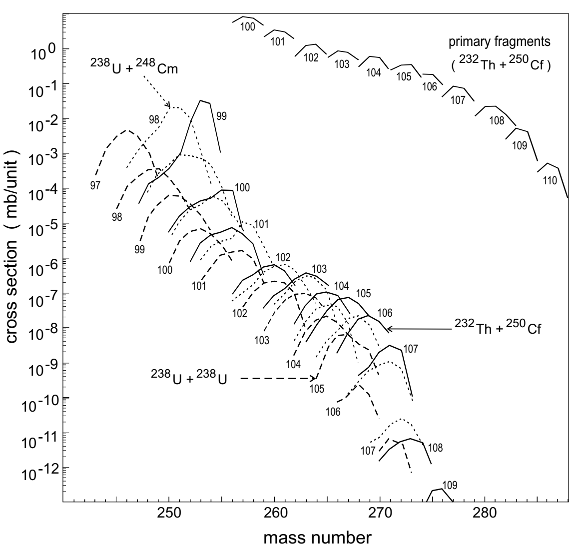

Figure 1: Yield of superheavy nuclei in collisions of ^{238}U+^{238}U (dashed), ^{238}U+^{248}Cm (dotted) and ^{232}Th+^{250}Cf (solid lines) at 800 MeV center-of-mass energy. Solid curves in upper part show isotopic distribution of primary fragments in the Th+Cf reaction. In the case of U+Cm the upper curve only is marked by Z-number (Z=98), the others are one by one up to Z=107.

Low energy collisions of very heavy nuclei (^{238}U+^{238}U, ^{232}Th+^{250}Cf and ^{238}U+^{248}Cm) have been studied within the proposed dynamical model. Large charge and mass transfer was found due to the "inverse" (anti-symmetrized) quasi-fission process caused by the Z=82 and N=126 nuclear shells. The production of survived long-lived neutron-rich superheavy nuclei in collisions of transuranium ions seems to be quite possible due to this quasi-fission process (see Fig. 1). Radiochemical identification of ^{267,268}Db and ^{271,272}Bh isotopes, produced in the Th+Cf or U+Cm reactions, could be performed, for example, to test this conclusion. If the found cross sections will be higher than several picobarns, then the subsequent experiments with such reactions could be planned aimed to the production of superheavy nuclei just in the region of the "island of stability".

Parallel search for spontaneous positron emission from a supercritical electric field of long-living giant quasi-atoms formed in these reactions is also quite promising. In many events lifetime of the composite system consisting of two touching nuclei turns out to be rather long (see reaction time distribution in Fig. 2); sufficient for spontaneous positron formation from super-strong electric field, a fundamental QED process.

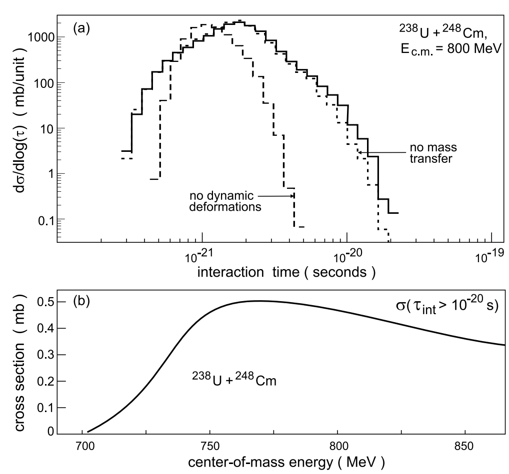

Figure 2: (a) Reaction time distribution for the ^{238}U+^{248}Cm collision at 800 MeV center-of-mass energy. Dashed and dotted histograms show the effect of switching-off dynamic deformations or mass transfer, respectively. (b) Cross section for events with interaction time longer than 10^{-20} s depending on beam energy.