Formation of superheavy elements in heavy-ions collisions

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The process of the synthesis of *superheavy elements* (SHEs) is not yet understood completely. In the presented work [1,2] we make an attempt to describe the cold fusion reactions of the type X + (Pb,Bi) → SHE + 1n at subbarrier and near barrier energies. The process of the formation of SHEs is subdivided into three steps. 1. The capture of two spherical nuclei and the formation of a common shape of the two touching nuclei. Low-energy surface vibrations and transfer of few nucleons are taken into account in the first step of the reaction. 2. The formation of a spherical or near spherical compound nucleus. 3. The surviving of the excited compound nucleus due to evaporation of neutrons and γ-ray emission in competition with fission. The following reactions were analyzed in detail: (^{58}Fe, ^{64}Ni, ^{70}Zn, ^{78}Ge) + ^{207}Pb, (^{50}Ti, ^{54}Cr, ^{58}Fe, ^{59}Co, ^{62,64}Ni, ^{65}Cu, ^{66,68,70}Zn, ^{71}Ga, ^{74,76,78}Ge, ^{75}As, ^{80,82}Se, ^{86}Kr, ^{87}Rb, ^{88}Sr) + ^{208}Pb, (^{58}Fe, ^{64}Ni, ^{70}Zn, ^{78}Ge) + ^{210}Pb and (^{50}Ti, ^{54}Cr, ^{58}Fe, ^{64}Ni, ^{70}Zn, ^{78}Ge, ^{86}Kr) + ^{209}Bi. The presented model describes well the available experimental cross-section data for elements with Z=104-112,118 (see fig also) and allows for predicting cross-section values for the synthesis of so far unknown heavier elements.
The SHE production in reactions with similar target and projectile [(^{124}Sn, ^{130,136}Xe) + ^{136}Xe] is considered. Reactions with similar target and projectile may be very important for determination of chemical properties of SHEs due to high reaction cross sections, see fig. The calculations are made for two different values of inner barrier, which taken place at the shape evolution stage.

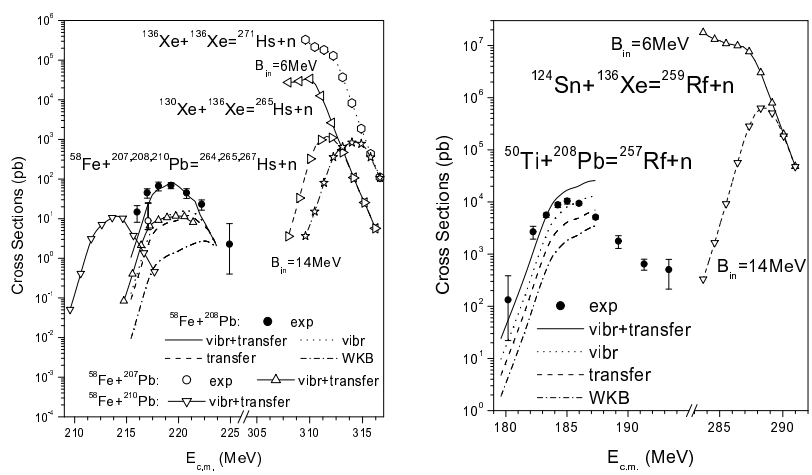

FIG. 1. Calculated excitation functions for the reactions ^{58}Fe+^{207,208,210}Pb →^{264,265,267}Hs+n and ^{130,136}Xe+^{136}Xe →^{265,271}Hs+n (left) and ^{50}Ti+^{208}Pb →^{257}Rf+n and ^{124}Sn+^{136}Xe →^{259}Hs+n (right). The continuous curve shows the results which take into account for both the low-energy 2^+ and 3^- vibrations and the neutrons transfer channels. For reactions ^{58}Fe+^{208}Pb →^{265}Hs+n and ^{50}Ti+^{208}Pb →^{257}Rf+n the dotted and the dashed curves show the results based on solely the 2^+ and 3^- vibrations and the neutron transfer channels, respectively. The results of the one-dimensional WKB approach last two reactions are shown by the dash-dotted curves. The results of calculations including both vibrations and transfer enhancements obtained for other reactions are additionally marked by symbols, see assignments in figs. The experimental data are taken from [3,4].

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