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Quasifission in heavy and superheavy element formation reactions

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Abstract. Superheavy elements are created in the laboratory by the fusion of two heavy nuclei. The large Coulomb repulsion that makes superheavy elements decay also makes the fusion process that forms them very unlikely. Instead, after sticking together for a short time, the two nuclei usually come apart, in a process called quasifission. Mass-angle distributions give the most direct information on the characteristics and time scales of quasifission. A systematic study of carefully chosen mass-angle distributions has provided information on the global trends of quasifission. Large deviations from these systematics reveal the major role played by the nuclear structure of the two colliding nuclei in determining the reaction outcome, and thus implicitly in hindering or favouring superheavy element production.

Superheavy elements (SHE) are formed by heavy-ion fusion reactions. Their cross sections are significantly suppressed [1] by the quasifission process [2]. This non-equilibrium process results when the combined di-nuclear system, formed initially when the two nuclear surfaces stick together, subsequently separates into two (fission-like) fragments. This occurs very rapidly, typically $\sim 10^{-20}$ s, well-before a compact compound nucleus is formed [2–4]. The probability of quasifission (P_{QF}) can be very large, thus the complementary probability of compound nucleus formation ($P_{CN} = 1 - P_{QF}$) can be lower than 10^{-3} in unfavourable cases. Understanding the competition between quasifission and fusion is thus very important in predicting the optimal fusion reactions to use to form new elements and isotopes in the superheavy mass region.

A key quantity characterizing the non-equilibrium quasifission process is the "sticking time" between contact of the two nuclear surfaces [5] and breakup (scission). Since the two colliding nuclei always approach each other along the beam axis, and after contact rotate

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