Ellipsoidal deformations and multiple-humped fission and fusion barriers of the heaviest elements

G. Royer

Laboratoire Subatech, UMR : IN2P3/CNRS-Université-Ecole des Mines,
4 rue A. Kastler, 44307 Nantes Cedex 03, France,
royer@subatech.in2p3.fr

Most of the fission, fusion, cluster and alpha emission data have been reproduced within a generalized liquid drop model which includes the nuclear proximity effects, the mass and charge asymmetry, an accurate nuclear radius and the microscopic corrections assuming compact and creviced quasi-molecular shapes for the one-body configurations and two separated spheres for the two-body shapes [1-5]. In the present study, the prolate and oblate ellipsoidal deformations of the fragments or incoming nuclei have been introduced and their effects on the multiple-humped fission and fusion potential barriers have been examined, mainly for the actinides and superheavy elements.

For the actinide nuclei, double and triple-humped fission barriers appear [6]. The second maximum corresponds to the transition from compact and creviced one-body shapes to two touching oblate ellipsoids. A third minimum and third peak appear in certain asymmetric exit channels, in accordance with recent experimental results [7]. This phenomenon takes place for fission path where one fragment is close to the doubly magic ${}^{132}_{50}\mathrm{Sn}$, its shape being almost spherical all along the exit channel, while the other non-magic fragment evolves from oblate to prolate shapes. The third peak corresponds to the two touching spherical fragments where the shell effects for the non-magical fragment are maximal. The barrier heights agree with the experimental results and the predicted half-lives follow the experimental data trend.

In cold fusion paths leading possibly to superheavy elements double humped fusion barriers stand and incomplete fusion events may occur in the second well. The height of the outer barrier is strongly reduced by the ellipsoidal deformations. The knowledge of the moment of emission of the excess neutrons is crucial to decide between complete fusion and fast fission. Warm fusion reactions lead to one-humped potential barriers and to very excited systems cooling down by neutron or even alpha-particle emission. The effects of the ellipsoidal deformations are less important in this more asymmetric entrance channel. Alpha-decay half-lives of superheavy elements have been calculated and compared with experimental data.

[1] G. Royer, K. Zbiri, Nucl. Phys. A 697 (2002) 630.
[2] G. Royer, B. Remaud, Nucl. Phys. A 444 (1985) 477.
[3] G. Royer, R. Moustabchir, Nucl. Phys. A 683 (2001) 182.
[4] G. Royer, J. Phys. G : Nucl. Part. Phys 26 (2000) 1149.

[5] G. Royer, R. A.. Gherghescu, Nucl. Phys. A. 699 (2002) 479.
[6] G. Royer, C. Bonilla, proceedings of the 8th International Spring Seminar on Nuclear Physics : Key topics in nuclear structure (Paestum, Italy, 2004) World Scientific p 559 and Heavy Ion Physics 2005, in the press.
[7] A. Krasnahorkay et al, Phys. Rev. Lett. 461 (1999) 15.