Dynamical calculation of multi-modal nuclear fission of Fermium Isotopes

T. Asano[1], T. Ichikawa[2], T. Wada[1], M. Ohta[1], S. Yamaji[3] and H. Nakahara[4]

1) Department of Physics, Konan University, 8-9-1 Okamoto, Kobe 658-8501, Japan
2) Japan Atomic Energy Research Institute, Tokai-Mura, Ibaraki 319-1195, Japan
3) Cyclotron Center, RIKEN, Wako, Saitama 351-0198, Japan
4) Graduate School of Science, Tokyo Metropolitan University, Tokyo 192-0397, Japan

It is reported that the mass distribution and total kinetic energy (TKE) distribution of nuclear fission fragments consist of the several components. It is thought that these components correspond to nuclear fission modes [1,2].

Y. L. Zhao et al. investigated the systematics of the average TKE value in the actinide region [1,2]. They deduced the shape elongation β that characterizes the fragment deformation. It was found that there are three types of scission configurations: mass-asymmetric deformation with β=1.53, mass-symmetric deformation with β=1.65, and the mass-symmetric compact deformation with β=1.33.

In order to understand multi-modal nuclear fission theoretically, we treat nuclear fission process dynamically. The shell correction energy is essential for the multi-modal nuclear fission. The potential energy is calculated using the macroscopic-microscopic method. The macroscopic part of the energy is calculated with the Yukawa plus exponential model and the microscopic part of the energy is calculated with the Strutinsky shell correction method using the two-center harmonic oscillator single-particle potential [3]. The excitation energy dependence of the shell energy is included. The multi-dimensional Langevin equation is used for the dynamical calculation in the three-dimensional parameter space, i.e., $R_{C.M.}$ (distance between fission fragments), δ (deformation of fission fragments), A_1 (mass number of fission fragment, and A_2 is mass number of other fission fragment).

Fission dynamics of fermium isotopes have been investigated. From the deformation distribution at scission point, we found that this distribution consists of several components and these components correspond to fission modes. We classified the deformation into the following three regions: the compact configuration ($\delta<0.04$), the medium configuration ($0.04<\delta<0.26$) and the elongated configuration ($\delta>0.26$). We have analyzed the mass and TKE distributions for each peak in the deformation distribution. The compact configuration ($\delta<0.04$) corresponds to a mass-symmetric fission with high TKE, the medium configuration ($0.04<\delta<0.26$) to a mass-asymmetric fission and the elongated configuration ($\delta>0.26$) to a broad mass-symmetric fission with low TKE. It is found that β deduced from the average TKE for each peak corresponds to the Zhao's experimental systematics. We conclude that the fragment deformation plays an important role together with the mass-asymmetric degree of freedom in analyzing fission modes.

[1] Y. L. Zhao et al., Phys. Rev. Lett. 82 (1999) 3408.
[2] Y. L. Zhao et al., Phys. Rev. C62 (2000) 014612.
[3] A. Iwamoto, S. Yamaji, S. Suekane and K. Harada, Prog. Theor. Phys. 55 (1976) 115.