6-2 New Fission Channel Opened in Reaction Using Deformed Nucleus ^{238}U
—Fission of Super-Heavy Nucleus ^{274}Hs—

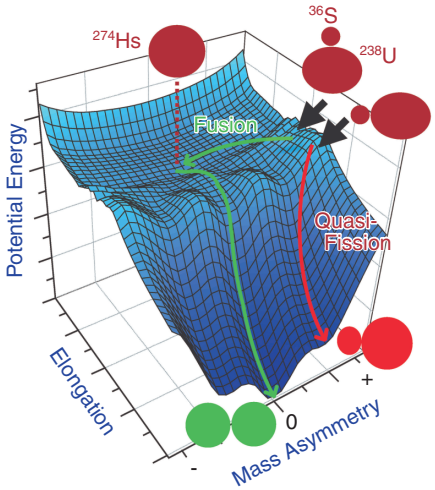

Fig.6-4 Potential energy surface for ^{274}Hs
The green curve is the fission channel from the compound nucleus, and the red curve is the quasi - fission channel. Competition between fusion and quasi-fission occurs, which depends on the colliding angle of ^{36}S with the symmetrical axis of ^{238}U.

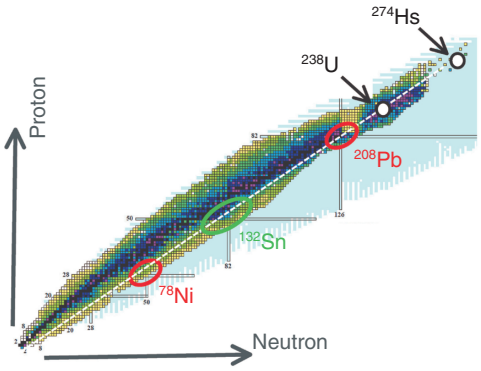

Fig.6-5 Chart of nuclei plotted according to neutron and proton number
In the fission of ^{274}Hs, asymmetric fission channel appears because of double closed shell nuclei, ^{208}Pb and ^{78}Ni. The symmetric fission channel is due to the closed shells of ^{132}Sn.

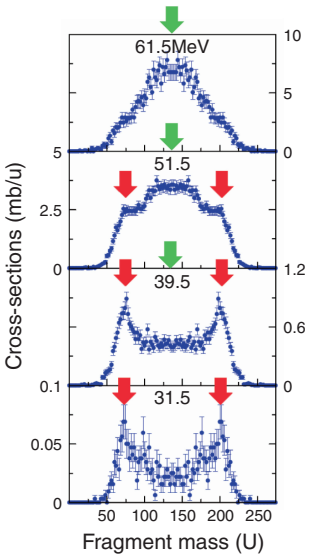

Fig.6-6 Fission fragment mass distributions in the reactions of ^{36}S + ^{238}U
Fragment yields centered at the green and red - arrows are associated from fusion-fission and quasi-fission, respectively.

Nuclear fission is a fundamental phenomenon for the use of nuclear power. The fragments of neutron-induced fission of uranium-235 (^{235}U) exhibit mass asymmetry. Even modern theory cannot predict this mass distribution, demonstrating that fission is still an unknown phenomenon.

Fission is considered to proceeds through a valley (channel) in the potential energy surface of the nucleus. In potentials calculated with the classical nuclear model, there are only mass-symmetric channels, which contradicts observations. A microscopic property (shell effects) must be taken into account to explain the mass-asymmetry.

In this work, fission of super-heavy nucleus hassium-274 (^{274}Hs, atomic number 108) was studied in order to investigate the effects of nuclear-shell on fission. In the potential energy map for ^{274}Hs in Fig.6-4, two distinct fission valleys are evident. One is the channel with mass-symmetry, occurring due to the shell around tin-132 (^{132}Sn), as indicated in Fig.6-5. The other is the mass-asymmetric channel of nickel-78 (^{78}Ni) and lead-208 (^{208}Pb), formed by double closed shells which appear only in super-heavy nuclei. To investigate this channel, we measured ^{274}Hs fission fragment mass distributions.

The ^{274}Hs was produced by bombarding sulfuer-36 (^{36}S) on uranium-238 (^{238}U). The experiment was carried out at the JAEA tandem accelerator at the Nuclear Science Research Institute. Two fission fragments produced by the reaction were detected simultaneously to determine the fragment masses. The results are shown in Fig.6-6. The upper figures show the results from higher bombarding energies. At the low energies, the distribution changes to mass asymmetry with peaks at 200/74 u. The results proved the presence of the new fission channel.

The energy dependence of the mass distributions in Fig.6-6 arises from the lemon-like deformation of ^{238}U as seen in Fig.6-4. At the high energies of ^{36}S, reaction occurs from every colliding angle. Symmetrical fission occurs after the compound nucleus is formed by fusion. At the low energies, reaction starts only from polar collisions and the system easily fissions through the asymmetric channel. Quasi-fission, i.e. fission without formation of a compound nucleus, was observed, proving the presence of the new fission channel.

Reference

Nishio, K. et al., Effects of Nuclear Orientation on the Mass Distribution of Fission Fragments in the Reaction of ^{36}S + ^{238}U, Physical Review C, vol.77, no.6, 2008, p.064607-1-064607-5.