The research objective of our group is to investigate heavy-ion induced reactions such as nucleon-transfer and fusion reactions. One subject is to develop experimental and theoretical methods to determine neutron-induced reaction cross sections with heavy-ion reactions. For nuclei with short half-lives, it is practically impossible to measure the cross sections in experiments using neutron source. The idea of the so-called surrogate reaction method is to populate the same compound nucleus as the neutron-capture reaction by nucleon-transfer reactions using available target nucleus and to measure the decay probabilities for fission and gamma-ray emission to derive fission and capture cross sections. In addition, nuclear fission and nuclear structure of exotic nuclei and reaction mechanism to produce exotic nuclei are in our scope.

**Neutron-induced fission cross section of short-lived nucleus $^{239}\text{U}$ determined by surrogate reaction method**

Neutron-induced fission cross sections for $^{239}\text{U}$ (half-life 23.5 min) were determined using the surrogate reaction technique. The compound nucleus $^{240}\text{U}^*$ was populated by the transfer-reaction $^{238}\text{U}(^{18}\text{O},^{16}\text{O})^{240}\text{U}^*$, and the fission probability of $^{240}\text{U}^*$ was determined experimentally. The fission cross sections were obtained by referring the known fission cross sections of $^{235}\text{U}(n,f)$ and measuring the fission probability of $^{236}\text{U}^*$ populated by the reaction $^{235}\text{U}(^{18}\text{O},^{17}\text{O})^{236}\text{U}^*$. The experiment was carried out at the JAEA tandem accelerator facility. A thin uranium target layer was bombarded by oxygen beams with 162 MeV. The transfer channel was identified by detecting the projectile-like nucleus using silicon ΔE-E detectors. Fission events were identified by detecting fission fragments with multi-wire proportional counters. The results are shown in Fig. 1.

**Reaction dynamics in collisions between heavy nuclei in the framework of fluctuation-dissipation model**

Exotic nuclei far from stable isotopes are produced by collisions between heavy nuclei. An example is super-heavy nuclei (SHN), which can be produced by fusion-evaporation reactions. Understanding the fusion process is essential to predict the cross section for SHN and to make an experimental strategy. We have developed a model to calculate the evolution of nuclear shape from the initial impact between a projectile nucleus and an actinide target nucleus in the framework of fluctuation-dissipation model [1]. The actinide nucleus is prolately deformed, so that we have effectively taken into account the orientation effects on the reaction. Figure 1 shows the time evolutions of nuclear shape for systems produced by the $^{30}\text{Si} + ^{238}\text{U}$ and $^{36}\text{S} + ^{238}\text{U}$ reactions. Fusion is defined as the case that the nuclear shape attains the one of ground state of SHN (compound nucleus). The calculation shows the difference between fusion-fission and quasifission in the mass asymmetry of fission fragments and in the time scale for fission. The fusion probability is obtained from the fusion-fission yield relative to the total fission yield. The probability agreed with those determined by the evaporation residue cross sections [2,3]. The same model successfully described the nucleon-transfer induced fission [4].

**References**