Determination of the limits of stability of heaviest nuclei is one of the topics not only the most interesting but also the most challenging in modern nuclear physics. The produced heaviest elements also open a unique opportunity in chemistry, where chemical/atomic properties are crucially determined by the strongly focusses toward addressing these fundamental relativistic effects. The research conducted by our group rich nucleus 178Pt [3]. We found two independent fission modes, i.e., different deformation paths in fission. One is the mass-asymmetric fission leading to average light (L) and heavy (H) fission-fragment masses, \( A_L/A_H \sim 79 \, \text{u}/99 \, \text{u} \), close to \( \sim 80 \, \text{u} /100 \) u observed in low-energy fission of \(^{180}\text{Hg} \), and the other is the mass symmetric fission, which shows the relatively low total kinetic energy (TKE), (see Fig.1). These two fission modes are well reproduced by nuclear density functional theory.

Origin of the dramatic change of fission mode in fermium isotopes investigated using Langevin framework

About 40 years ago, a very exciting result was found in the spontaneous fissions of fermium isotopes. In contrast to the mass-asymmetric fission of \(^{254}\text{Fm} \) and lighter isotopes, \(^{250}\text{Fm} \) shows sharp mass-symmetric fission. Sudden appearance of the sharp symmetric fission, only by adding just two extra neutrons, has not been explained quantitatively so far.

The mechanism becomes unveiled clearly using a Langevin framework [4]. The time evolution of the nuclear shape on the potential surface reveals that the lighter fermium isotope \(^{254}\text{Fm} \), without surmounting the saddle point B, (see Fig.2). This behavior changes dramatically in \(^{258}\text{Fm} \) that disintegrate immediately after overcoming the 1\textsuperscript{st} saddle point, whereas \(^{258}\text{Fm} \) disintegrates after overcoming the saddle point B, without surmounting the saddle point B. The fission path is determined by a subtle balance between the saddle point A and B. The second saddle point A, which prevents the fission of \(^{254}\text{Fm} \) in this direction, is lowered for \(^{258}\text{Fm} \), opening the compact and sharp symmetric fission.

The reaction of \(^{36}\text{Ar} + ^{142}\text{Nd} \) was used to study fission of proton-rich nucleus \(^{178}\text{Pt} \) [3]. We found two independent fission modes, Fission of a proton-rich nucleus has nowadays become a hot topic after the discovery of the mass-asymmetric fission of \(^{194}\text{Hg} \), (see our recent review [2]). Several experimental and theoretical results are revealing that there is a new island which is dominated by the mass-asymmetry in fission in addition to the well-known actinide region in the chart of nuclides. Fission data in the unexplored region were obtained by forming excited compound nuclei in heavy-ion fusion reactions at the JAEA tandem facility. Advantage of this approach is that fission of many nuclides can be investigated by selecting available targets and projectile nuclei, in contrast to the conventional \( \beta \)-delayed fission and/or fission after Coulomb excitation in inverse kinematics.

References