New territory in nuclear fission explored with ISOLDE

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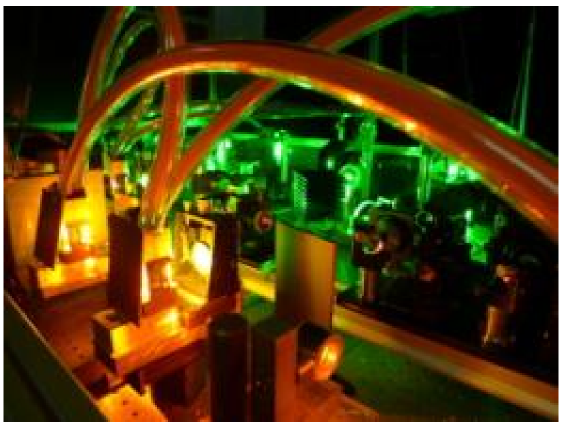

Resonance Ionization Laser Ion Source (RILIS) in action at ISOLDE. RILIS was instrumental in providing the pure beam necessary for the successful nuclear fission experiment.

An international collaboration led by the University of Leuven, Belgium, exploiting ISOLDE's radioactive beams, has recently discovered an unexpected new type of asymmetric nuclear fission, which challenges current theories. The surprising result opens the way for new nuclear structure models and further theories to elucidate the question.

In nuclear fission, the nucleus splits into two fragments (daughter nuclei), releasing a huge amount of energy. Nuclear fission is exploited in power plants to produce energy. From the fundamental research point of view, fission is not yet fully understood decades after its discovery and its properties can still surprise nuclear physicists.

The way the process occurs can tell us a lot about the internal structure of the nucleus and the interactions taking place inside the complex nuclear structure. In particular, processes in which fission is observed at an energy just above the minimum required are the most likely to tell us which quantum corrections should be applied to the liquid-drop model (classical description) to fully understand nuclear behaviour.

At ISOLDE, an international collaboration involving scientists from nine countries has been studying the 180Tl isotope. Via radioactive decay, the thallium isotope transforms into the 180 isotope of mercury (180Hg), which subsequently fissions. “According to previous experiments and related theoretical models, we were expecting a symmetric mass distribution of the fission fragments,” says A. N. Andreyev, the principal investigator from the KU Leuven team (presently working at the University of the West of Scotland). “However, we measured an asymmetric mass distribution of the fission fragments. This discrepancy is leading us to rethink our theories on the interplay between the macroscopic liquid-drop model and the microscopic single-particle shell corrections to apply in the description of these nuclei.”

The result follows other attempts to understand similar fission processes that were made about 20 years ago by scientists in Dubna. “Previous experiments had to deal with huge amounts of contaminants in the samples of the parent element. Using ISOLDE’s unique laser ion source that makes it possible to selectively ionize elements, we can obtain a high-purity sample of 180Tl (T1/2=1.1 s). This allows us to determine with an unprecedented accuracy the different branching ratios of the various decays,” explains Andreyev.

The unexpected result of ISOLDE’s experiment will stimulate the development of new theoretical approaches to the fission process. “We have worked on a new description of the internal structure of the Hg nucleus, which is able to predict the asymmetric mass splits that we have observed. Further experiments and new theories are needed to elucidate the dynamics of the fission processes, at least for nuclei located in the region around thallium in the nuclei chart," concludes Mark Huyse, another member of the team from KU Leuven.

Provided by CERN