Direct Mass Measurements of Short-Lived Neutron-Rich Fission Fragments at the FSR-ESR Facility at GSI

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Masses of more than 280 neutron-rich isotopes have been measured in the Isochronous Mass Spectrometry (IMS) and 41 experimental mass values were determined for the first time. Fission of relativistic uranium projectiles in a beryllium target was used as a source for neutron-rich nuclei. They were separated in-flight with the fragment separator FRS, and injected into the storage ring ESR, that was operated in the isochronous mode as a high-resolution time-of-flight mass spectrometer. Highly-charged ions have been measured simultaneously as a mixture of nuclides with well-known masses and masses to be determined.

In this first production run a mass resolving power of 2.5×10^5 was achieved for ions with the best isochronicity. The uncertainties in mass determination reached a level between 140 and 400 keV. Although ^{93}Br with $T_{1/2}$=102 ms was the nuclide with the shortest known half-life, that we have observed, the method provides possibility to measure masses with half-lives as short as 100 μs.

The region of the new masses is near the r-process path and our values are useful for predictions of the correct mass values for nuclides which form the r-process. Comparisons with various mass predictions show discrepancies growing towards the more exotic neutron-rich regions (see, e.g. Fig. 1). Masses of ^{109}Nb and ^{114}Tc show deviation of 1.5 MeV from the extrapolations [1].

The measurement of fission products covered a large area of nuclides and showed the potential of the IMS technique. This pioneering experiment in the area of neutron-rich nuclides showed, that this region is not well described by present theories (see also B. Pfeiffer and K.-L. Kratz [5]). Therefore mass measurements of neutron-rich nuclides are an important task for nuclear structure physics and astrophysics.

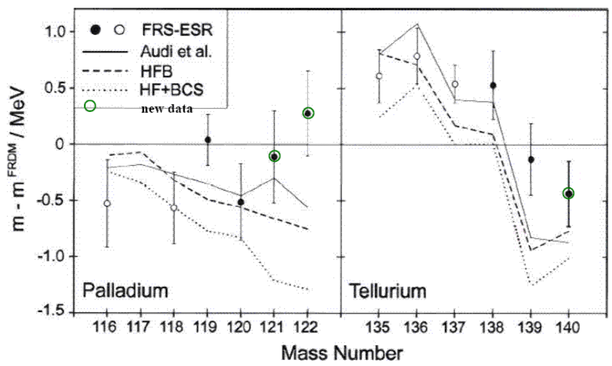

Figure 1: Comparison of measured masses of neutron-rich Palladium and Tellurium isotopes with the new mass evaluation of Audi et al. [1] and two recent mass models, HF+BCS [2] and HFB [3], respectively. Differences to the FRDM masses from Ref. [4] are displayed.

References

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