TASCA 18
GSI, Darmstadt, September 25, 2018
17th Workshop on
Recoil Separator for Superheavy Element Chemistry

Penning-Trap Mass Spectrometry of the Heaviest Elements with SHIPTRAP

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One of the fundamental questions in nuclear physics concerns the existence and properties of the heaviest elements. To solve such a puzzle, it is essential to investigate the nuclear shell effects that counteract spontaneous fission and determine the stability of such exotic systems.

High-precision Penning-trap mass spectrometry (PTMS) is an established tool for investigations of shell effects and their evolution for nuclear systems with different proton to neutron ratios through direct measurements of the atomic masses and hence binding energies [1]. The heaviest elements investigated to date in pioneering experiments with the SHIPTRAP setup at GSI, have been nobelium and lawrencium [2,3]. The direct measurement of the masses of $^{252-255}$No and ^{255,256}Lr has allowed mapping the strength of the deformed subshell closure at N=152.

Recent developments of the setup allowed pushing these limits to even heavier and more exotic nuclei in the latest beam time at GSI (June-July 2018) when the mass of the first super-heavy element, ^{257}Rf (Z=104) was directly measured for the first time. The SHIPTRAP efficiency has been boosted by the implementation of a cryogenic gas-catcher with increased stopping and extraction ion efficiency [4]. The mass resolving power, precision and detection sensitivity has been further enhanced by the development, at SHIPTRAP, of the Phase-Imaging Ion-Cyclotron-Resonance technique [5,6]. This state-of-the-art method allowed also, during the same experiment, to simultaneously measure ground and low-lying isomeric states of the heaviest elements, which are often not accessible by other techniques.

The setup upgrade as well as the latest results and the related new piece of information concerning the shell structure of the heaviest elements will be discussed together with the future plans.

References

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