# Heavy element research with laser spectroscopy and traps

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Recoil separators like the SHIP facility at GSI in Darmstadt open a great variety of new research opportunities in the heavy element research if combined with traps in which the fusion products can be stored.

The simplest conceivable trap is a buffer gas cell in which the fusion products come to rest either as atoms or singly charged ions. The capture time of the neutral atoms is determined by the diffusion process to the walls. This time of typically 50 ms is long enough to investigate the unknown atomic level schemes or determine the ionization potential of heavy elements by laser spectroscopy employing pulsed lasers with repetition rates of 20 Hz or more. Very powerful methods have been developed like the resonance ionisation spectroscopy with detection of the ionization process either by radioactive decay [1] or directly after mass analysis [2]. The combination of experimental search for atomic levels in the heavy actinide and transactinide region with theoretical level predictions based on Multi-Configuration-Dirac-Fock calculations may provide a critical test of such ab-initio calculations of electron configurations. Once excited atomic states are known, the hyperfine structure of suitable transitions can be studied as well enabling stringent tests of nuclear models applied to the heaviest nuclei.

The fraction of singly charged ions can be used to study gas phase ion chemical reactions with admixtures like $O_2$, $H_2O$, $CH_4$ … to the buffer gas in the stopping chamber. A measurement of the drift time of the ions or ionic compounds in the buffer gas chamber enables a determination of the ionic mobility and may open up new avenues in studies of relativistic effects on ionic radii and the bond length of simple molecular ions [3]. It is conceivable that such investigations can be extended to transactinides with lifetimes larger than 10 ms produced with cross-sections greater than about 100 pb.

A high-resolution Penning trap mass spectrometer as proposed for the SHIPTRAP facility [4] allows direct mass spectrometry of heavy actinide and transactinide isotopes. Traps with small amounts of reactive gases may also provide access to kinetic studies by investigating the loss rate of stored heavy ions and the formation of ion chemical compounds.

## References

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