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High resolution laser spectroscopy in the actinide region using the PI-LIST laser ion source

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The resonance ionization laser ion sources RILIS, pioneered by V.S. Letokhov and his group in the 1980ties, have since found wide applications at all on-line isotope separator facilities worldwide. This success is based on the excellent specifications of ultimate ionization efficiency, realized for most elements of the periodic table, combined with very high selectivity achieved by suppressing unwanted isobars to a minimum in the ionization process.
The advent of tunable lasers with high power, high repetition rate and easy operation, which cover the entire spectral range from UV to far IR and which can universally be adapted to individual atomic spectra and scientific tasks, has led to further superb progress in this field in recent decades. In addition to the efficient production of pure ion beams of radioisotopes for fundamentals studies or nuclear medicine, e.g. at the CERN radioactive beam facilities (RIB) ISOLDE (on-line) or MEDICIS (off-line), or the collection of ultrapure radioisotope samples as calibration sources, carried out e.g. at the RISIKO off-line RIB at University of Mainz, meaningful optical spectroscopy within the laser ion source unit has become possible. By adequate design of the laser-atom interaction region and adaptation of the laser specifications, high-resolution spectroscopy has been demonstrated the PI-LIST version of the RILIS.
In the last years, the technologies of RILIS, LIST and PI-LIST have been applied at the off-line radioisotope beam (RIB) facility RISIKO at University of Mainz for studies on actinide isotopes of the elements 89Ac up to 100Fm. The PI-LIST studies yield hyperfine structures and isotope shifts on top of the basic atomic physics data from the RILIS, both being so far scarce in this region of the periodic table. Involving theoretical support, the analysis of the high resolution data yields spins, nuclear moments, and changes of mean-squared nuclear charge radii. This information contributes to an understanding of the hitherto largely unknown nuclear physics landscape in this area of very heavy elements and provides guidance for ongoing activities in the range of the heaviest actinides Md, No, and Lr up to the super-heavy elements 1.
A short introduction into the technical prerequisites for high resolution spectroscopy within the PI-LIST laser ion source will be given, addressing both off-line and on-line operation, and the spectroscopic results will be discussed with a focus on the nuclear structure of actinide elements.
1 M. Block, M. Laatiaoui, S. Raeder, Prog. Part. Nucl. Phys. 116, 103834 (2021). https://doi.org/10.1016/j.ppnp.2020.103834

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