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The PI-LIST: High-resolution crossed-beams laser spectroscopy inside the ISOLDE laser ion source

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Laser resonance ionization spectroscopy in the ion source coupled directly to the isotope production target has been proven to be a highly sensitive tool for nuclear structure investigations on isotopes with low production and extraction yields [1]. While the efficiency of this technique is unrivalled, the spectral resolution is ultimately limited by Doppler broadening. At the ion source temperature of ˜2000 ℃ typically required for efficient operation, Doppler broadening results in a 1-10 GHz experimental resolution limit whereas precise measurements of nuclear magnetic and quadrupole moments often require resolving hyperfine structure splittings below the GHz regime.
A new laser ion source design has been implemented at ISOLDE recently to provide in-source spectroscopy capabilities down to experimental linewidths of 100 −200 MHz, an order of magnitude below usual limitations. It is based on the high beam purity Laser Ion Source and Trap (LIST) [2, 3], featuring spatial separation of the hot cavity where potential ion beam contamination can arise from non-laser related ionization mechanisms such as surface ionization. Laser-atom interactions take place in an RFQ structure directly downstream, where solely element-selective laser ionization takes place. In the so-called Perpendicularly Illuminated LIST (PI-LIST) [4] a crossed laser/atom beam geometry is used for spectroscopy, therefore only the transverse velocity spread of the effusing atom ensemble contributes to the experimentally observed Doppler broadening.
Following the integration of this device as the standard tool for high-resolution spectroscopy applications at the off-line mass separator facility at Mainz University [5, 6], we present its first online application at ISOLDE for nuclear structure investigations. Neutron-rich actinium isotopes in the region of assumed octupole deformation [7] were studied with the highest spectral resolution ever achieved for in-source resonance ionization spectroscopy at ISOLDE.
The applicability of this technique to ISOL facilities in general, its limits especially in terms of significant efficiency loss, and technical implementation challenges are discussed.

References

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