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High-resolution Laser Ionisation Spectroscopy of Heavy Elements in Supersonic Gas Jet Expansion

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Resonant laser ionization and spectroscopy are widely used techniques at radioactive ion beam facilities to produce pure beams of exotic nuclei and measure the shape, size, spin and electromagnetic multipole moments of these nuclei. In such measurements, however, it is difficult to combine a high efficiency with a high spectral resolution. Recently, we have demonstrated the on-line application of atomic laser ionization spectroscopy in a supersonic gas jet, a technique suited for high-precision studies of the ground- and isomeric-state properties of nuclei located at the extremes of stability [1]. A significant improvement in the spectral resolution by more than one order of magnitude was achieved in these experiments without loss in efficiency.

Spatial constraints and limitations of the pumping system in the present setup prevented a high quality jet formation and, as a consequence, an optimal spatial and temporal laser-atom overlap. Offline characterization studies at the newly commissioned In-Gas Laser Ionization and Spectroscopy (IGLIS) laboratory at KU Leuven [2] are being carried to overcome these limitations in future experiments when dedicated IGLIS setups are in operation at new generation radioactive beam facilities [3]. These studies also include the characterization of the flow dynamics and the formation of supersonic jets produced by de Laval nozzles with different Mach numbers using the Planar Laser Induced Fluorescence technique on copper isotopes, the test of a new gas-cell design with better transport and extraction characteristics and the characterization of a high-power, high-repetition rate laser system. Extrapolation of the online results on the actinium isotopes show that the performance of the technique under optimum conditions can reach a final spectral resolution of 100 MHz (FWHM) and an overall efficiency of 10% when applied in the actinide region.

In this presentation we will briefly summarize the on-line results and mainly will focus on the characterization studies and future prospects of the in-gas-jet resonance ionization technique applied on very-heavy elements.

References:

[1] R. Ferrer et al., Nat. Commun.8, 14520 doi: 10.1038/ncomms14520 (2017).

[2] Yu. Kudryavtsev et al. Nucl. Instr. Meth. B 376, 345–352 (2016).

[3] R. Ferrer et al., Nucl. Instr. Meth. B 317, 570–581 (2013).

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