Contribution ID: **192** Type: **Oral Presentation**

Implementation of Laser Resonance Chromatography at S3

Atoms of different chemical elements possess spectra that serve as their unique fingerprints. Our knowledge of their spectra has allowed the identification of heavy elements in extragalactic stars, and even in neutron star mergers where half of the elements are thought to be produced.
Till date, very little is known about the atomic structure of the heaviest elements, which can only be synthesized in trace amounts in nuclear fusion-evaporation reactions. With such scarce yields, spectroscopy must be done "one atom at a time", for which traditional fluorescence methods lack sensitivity. Similarly, and despite the fact that resonance ionization spectroscopy has been successfully applied to a few atoms of nobelium (Z=102) [1] and, more recently, to fermium (Z=100) [2], it would still require groundbreaking developments before it can be applied to refractory metals of the d-block elements, which lay ahead.
The recently developed Laser Resonance Chromatography (LRC) technique could remedy this [3]. It exploits electronic state-resolved chromatography to measure the change in the ground state population by laser resonance excitation of sample ions to their higher excited levels, so that neither fluorescence detection nor resonance ionization is required for spectroscopy. The spectral precision of the method, combined with its high sensitivity, will enable the study of the atomic structure of the heaviest elements, in particular those beyond nobelium, and additionally will help to elucidate the evolution of nuclear charge radii and deformation in neutron-deficient isotopes of many transition metals that are so far out of reach or more challenging for conventional techniques.
In my contribution I will explain the LRC technique and show the future prospects for its implementation at the S3 installation of GANIL/SPIRAL2 for the spectroscopy of neutron-deficient actinium (Z=89) and lawrencium (Z=103) isotopes.

References:

[1] M. Laatiaoui et al., Nature 538 (2016) 495.
[2] J. Warbinek et al., Nature 634 (2024) 1075.
[3] M. Laatiaoui et al., PRL 125 (2020) 023002.

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Session Classification: Parallel session

Track Classification: Accelerators and Instrumentation