A novel laser spectroscopy technique for observing the most exotic nuclei

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The assumption of universal magic numbers, i.e. closed nuclear shells, all across the nuclear chart has been a fundamental paradigm of the nuclear shell model. However, when exploring nuclides far away from stability, a disappearance of well-established shell closures can be encountered, which, for instance, manifests itself in the island of inversion around $N = 20$ [1].

Describing this shell evolution from first principles is a formidable task for nuclear theory. Recently, nuclear ab-initio methods have been able to expand their reach also into open shell nuclei. This advance now allows for ab-initio calculations of nuclear observables within the $N = 20$ island of inversion [2]. In order to deepen our understanding of this region of nuclides and challenge the predictive power of modern nuclear theory, experimental knowledge about the nuclear charge radii of neutron-rich magnesium ($Z = 12$) isotopes is crucial.

A powerful tool to access nuclear charge radii is collinear laser spectroscopy (CLS) [3]. However, to extend previous measurements [4] and explore the most exotic nuclides like $^{33,34}Mg$ with very low production yields at radioactive ion beam facilities, more sensitive methods have to be envisioned.

The novel MIRACLS project at ISOLDE/CERN [5] combines the high spectral resolution of conventional fluorescence-based CLS with high experimental sensitivity. This is achieved by trapping ion bunches in an unprecedented 30 keV Multi-Reflection Time of Flight (MR-ToF) device, in which the ions bounce back and forth between two electrostatic mirrors. Hence, the laser-ion interaction time is increased with each revolution in the MR-ToF apparatus, while retaining the high resolution of CLS.

The new experimental setup consists of a buffer-gas filled Paul trap for providing cooled ion bunches, an offline ion source and the first MR-ToF device operated at 30 keV, with built-in optical detection region and laser access.

This poster contribution will introduce the MIRACLS concept, show the experimental setup and present the first measurements.

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