Contribution ID: **167** Type: **Oral invited talk**

MR-ToF Devices: New Applications and Developments

Thursday, 23 October 2025 10:30 (30 minutes)

Over the past 15 years, Multi-Reflection Time-of-Flight (MR-ToF) devices have established themselves as indispensable instruments for mass measurements and mass separation of short-lived radionuclides at radioactive ion beam (RIB) facilities. Within the MIRACLS collaboration at ISOLDE/CERN, we have expanded the use of MR-ToF devices, adapting them for highly sensitive collinear laser spectroscopy (CLS). By storing ions between the two electrostatic mirrors of an MR-ToF device, the same ion bunch is probed by a laser thousands of times compared to a single passage in traditional CLS [1,2]. The resulting increase in experimental sensitivity allowed us to access nuclear charge radii of neutron-rich magnesium isotopes, which were out of reach for conventional CLS due to their very low production yields. These measurements offer new insights into the island of inversion and provide stringent benchmarks for nuclear theory. Additionally, we measured the electron affinity of 35Cl with comparable precision to the literature value [3] despite utilizing five orders of magnitude fewer ions. This opens the door to future electron affinity studies of superheavy elements as well as across isotopic chains, which will challenge the predictive power of fully relativistic many-body quantum theories.

The development of the high-voltage MR-ToF device for MIRACLS, capable of storing ions at beam energies exceeding 10 keV as required to preserve the high resolution of conventional CLS, is also of great interest for achieving highly selective and high-flux MR-ToF mass separation. Simulations show that the ion throughput can be enhanced by more than 2 orders of magnitude when increasing the kinetic energy of the stored ions to 30 keV and when improving the MR-ToF design [4,5]. MIRACLS high-voltage MR-ToF device is hence foreseen to be repurposed as a mass separator at ISOLDE, while a dedicated 30 keV MR-ToF device is in development at FRIB to provide isobarically and isomerically purified beams at high rates to subsequent experiments.

This contribution presents the highly sensitive laser spectroscopic measurements at MIRACLS and outlines the design, development status, and the planned first science cases of FRIB's highly selective and high-flux MR-ToF mass separator.

[1] S.Sels et al., NIMB 463, 310-314 (2020)
[2] F.M.Maier et al., NIMA 1048, 167927 (2023)
[3] U.Berzinsh et al., Phys. Rev. A 51, 231 (1995)
[4] F.M.Maier et al., NIMA 1056, 168545 (2023)
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Classification

Ion traps and laser techniques

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Session Classification: Ion traps & laser techniques II

Track Classification: Ion traps and laser techniques