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MIRACLS - Laser spectroscopy of radioactive isotopes in an MR-ToF device

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The phenomenon of shell closures corresponding to increased stability of nuclei at magic numbers of protons or neutrons (2, 8, 20, 50, etc.) is a key feature of the nuclear shell model. However, conventional shell closures can disappear for radioactive nuclei in several key regions of the nuclear chart known as "islands of inversion."These islands provide ideal testing grounds for modern nuclear theory. In order to make use of them, precise experimental data is necessary for short-lived exotic nuclei. In particular, for the island of inversion in the neutron-rich region around $N = 20$, measurements of the charge radius of the magnesium isotopic chain, especially the ones beyond the shell closure such as ^{33,34}Mg, are crucial to perform accurate theoretical benchmarks.

Collinear Laser Spectroscopy is a highly effective tool for precise measurements of nuclear ground state properties of radionuclides such as the nuclear spin, electromagnetic moments, and charge radius. The Multi Ion Reflection Apparatus for Collinear Laser Spectroscopy (MIRACLS) is a new experimental setup at ISOLDE which aims to improve the sensitivity of conventional CLS by conducting it in a high-energy (> 10 keV) multi-reflection time-of-flight (MR-ToF) device [1, 2]. This is a type of ion trap which utilizes two electrostatic mirrors to reflect ion bunches back and forth for several thousands of revolutions. Hence, the ion bunches can be probed by the laser multiple times per measurement cycle to obtain higher statistics than with conventional CLS, which can study the ion bunch only once. The resulting improvement in sensitivity allows the exotic magnesium isotopes with yields as low as 100 ions per μC to become accessible.

Earlier this year, MIRACLS had a successful commissioning beamtime, where CLS on the radioactive isotopes ^{28,30,32}Mg was performed for both the D1 and D2 ionic transitions. This data has demonstrated the feasibility of the measurement of ^{34}Mg. In this oral contribution, I will discuss the MIRACLS concept and the latest experimental results, including CLS of short-lived radioactive Mg isotopes.

References

[1] Simon Sels et al. "First steps in the development of the multi ion reflection apparatus for collinear laser spectroscopy". In: NIMA B 463 (2020), pp.310-314.
[2] F.M. Maier et al. "Simulation studies of a 30-keV MR-ToF device for highly sensitive collinear laser spectroscopy". In: NIMA A 1048 (2023).

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