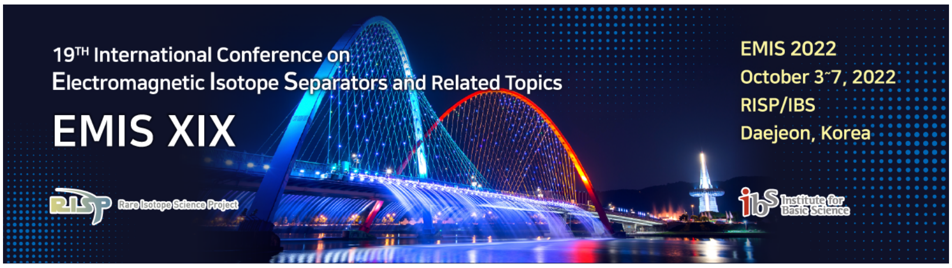

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Developments towards high-resolution laser spectroscopy of 235mU

Monday, 3 October 2022 22:46 (8 minutes)

Among the numerous isomers hidden within the landscape of the nuclear chart, ^{235m}U is the second lowest in energy, with the lowest being the well-known ∼8-eV ^{229m}Th isomeric state. The study of these isomers via high-resolution laser spectroscopy provides a valuable insight into their nuclear properties, such as nuclear mean-squared charge radii and nuclear electromagnetic moments. This information presents a challenge to state-of-the-art nuclear and atomic theory and is therefore needed to improve the predictive capabilities and to benchmark present models. In this respect, the actinide region is of particular interest but it poses special production challenges.

Within this context, a measurement campaign has been started at the IGISOL facility [Moore2014], University of Jyväskylä, Finland, aimed at measuring properties of the ^{235m}U 76-eV isomeric state via high-resolution laser spectroscopy. This will be achieved with the IGISOL collinear spectroscopy beamline [deGroote2020], in which a 30-kV accelerated ion beam is overlapped with a counterpropagating continuous wave laser beam, Doppler shifted to the resonance wavelength. The spectroscopic resolution achieved is sufficient to resolve hyperfine structures and isotope shifts, being close to the natural linewidth of the studied transitions.
The production of a ^{235m}U beam will be achieved using a ^{239}Pu alpha-recoil source, developed at the Johannes Gutenberg University, Mainz. The isomer is populated via alpha decay from ^{239}Pu with a summed branching ratio close to 100\%. The source will be mounted in the IGISOL actinide gas cell [Pohjalainen2016,Pohjalainen2020] and ^{235m}U recoils will be stopped, thermalized and extracted in a helium gas flow. After acceleration and mass separation, bunched beams of ions will be formed in the radiofrequency quadrupole cooler (RFQ) and transported to the collinear laser spectroscopy beamline.

Before the isomer measurement, a full characterization of the suitable optical transitions is needed. A set of 12 ionic transitions in the wavelength range from 288 to 314 nm has been studied, using the three natural isotopes of uranium: ^{234}U, ^{235}U and ^{238}U. In parallel, the recoil sources have been characterized using a variety of material based analysis techniques, nuclear decay spectroscopy and ion counting methods to quantify the recoil ion yield. In this contribution, we will summarize these two aspects of the project and provide an outlook to the forthcoming isomeric measurement.

[Moore2014] Moore, I. D. et al., Hyperfine interactions, 223 (2014): 17-62.
[deGroote2020] de Groote, R. P. et al., NIM B, 463 (2020): 437-440.
[Pohjalainen2016] Pohjalainen, I. et al., NIM B, 376 (2016): 233-239.
[Pohjalainen2020] Pohjalainen, I. et al., NIM B, 484 (2020): 59-70.

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