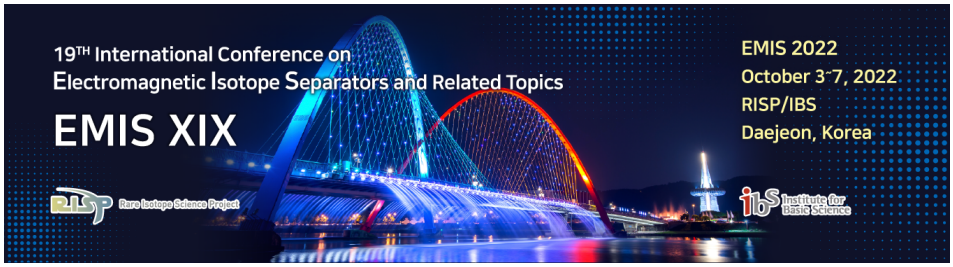

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Ultraviolet Spectroscopy of the Actinium-229 beta decay: the first observation of the radiative decay of the 229Th low-energy isomer

Tuesday, 4 October 2022 11:30 (20 minutes)

A unique feature of thorium-229 is its isomeric first excited state with an exceptionally low excitation energy, proposed as a candidate for future nuclear optical clocks [1]. The small nuclear moments are expected to outperform the accuracy of current state-of-the-art atomic clocks by about an order of magnitude [2]. The current best values of the excitation energy are 8.28(17) eV and 8.10(17) eV[3,4]. These were determined using two different measurement techniques whereby the isomer is populated in the alpha decay of uranium-233. The development of an optical clock requires, however, knowledge of the excitation energy by at least an order of magnitude more precise. Spectroscopic experiments searching for a direct signature of the radiative decay have to-date been unsuccessful, partially due to the background induced in the preceding alpha decay.

An alternative approach using the beta decay of actinium-229 is studied as a novel method to populate the isomer with high efficiency and in low background conditions [5]. Produced online at the ISOLDE facility, actinium is laser-ionized and implanted into a large-bandgap crystal in specific lattice positions, suppressing the electron conversion decay channel of the isomer. A favourable feeding pattern is significantly increasing the population of the isomer compared to uranium-233 and the lower energy deposit of the beta compared to the alpha decay results in a significantly reduced luminescence background.

In this contribution, a dedicated setup for the implantation of a francium/radium/actinium-229 beam into large-bandgap crystals and the vacuum-ultraviolet spectroscopic study of the emitted photons will be presented. From the results obtained during a first measuring campaign using MgF_2 and CaF_2 crystals as host material it can be concluded that the radiative decay of the thorium-229 isomer has been observed for the first time, the excitation energy of the isomer has been determined with a factor of 5 improved uncertainty and the ionic lifetime in a crystalline environment was determined.

[1] E. Peik et al., Europhys. Lett. 61, 2 (2003)
[2] C. Campbell et al., PRL 108, 120802 (2012)
[3] B. Seiferle et al., Nature 573, 243-246 (2019)
[4] T. Sikorsky et al., PRL 125, 142503 (2020)
[5] M. Verlinde et al., Physical Review C, 100, 024315 (2019)

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