Contribution ID: **6**

Type: **Talk**

Status and Perspectives for a Nuclear Clock based on the 229mTh isomer

Monday, 2 May 2022 15:30 (30 minutes)

Today's most precise time and frequency measurements are performed with optical atomic clocks. However, it has been proposed that they could potentially be outper-formed by a nuclear clock, which employs a nuclear transition instead of an atomic shell transition. There is only one known nuclear state that could serve as a nuclear clock us-ing currently available technology, namely the isomeric first excited state of 229Th. Evi-dence for its existence until recently could only be inferred from indirect measurements, suggesting since 2009 an excitation energy of 7.8(5) eV, representing the lowest nuclear excitation so far reported in the whole landscape of known isotopes. In 2016, the first di-rect detection of this nuclear state could be realized via its internal conversion decay branch, laying the foundation for precise studies of its decay parameters [1]. Subse-quently, a measurement of the half-life of the neutral isomer was achieved, confirming the expected reduction of 9 orders of magnitude compared to the one of charged 229mTh [2]. Collinear laser spectroscopy was applied to resolve the hyperfine structure of the thorium isomer, providing information on nuclear moments and the nuclear charge radius [3]. Most recently, also the cornerstone on the road towards the nuclear clock, which is a precise and direct determination of the excitation energy of the isomer, could be achieved by locating the isomeric excitation energy as 8.19(12) eV [4,5].
Hence major progress on the properties of this elusive nuclear state could be achieved in recent years, opening the door towards an all-optical control and thus the development of an ultra-precise nuclear frequency standard. Such a nuclear clock promises intriguing applications [6] in applied as well as fundamental physics, ranging from geodesy and seismology to the investigation of possible time variations of fundamental constants and the search for Dark Matter.
The collaborative project 'ThoriumNuclearClock', funded by the European Union, recently embarked to consolidate and improve our knowledge on the thorium isomer, to realize a first prototype of a Nuclear Clock and apply it to fundamental physics studies [7]. The talk will review recently completed, ongoing and planned activities towards this goal.

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Session Classification: The Intriguing 229Th Isomer