Contribution ID: **33** Type: **contributed talk**

Production of highly charged and molecular thorium ions for fundamental physics

Wednesday, 10 May 2023 15:00 (20 minutes)

Thorium isotopes became of high interest in the search for fundamental physics and for testing of the standard model of particle physics because of their unique nuclear and atomic properties [1,2]. In the project *Trapping And Cooling of Thorium Ions via Calcium* (▨▨▨▨▨▨▨), ion trapping and spectroscopic techniques are developed for a precise determination of nuclear moments, hyperfine intervals, and isotope shifts with different Th isotopes [3]. Two methods are used to produce atomic thorium ions, i. e., laser ablation of macroscopic thorium samples [3] and thin layers of alpha-decaying uranium isotopes which produce thorium daughter nuclei that recoil from the sample with the momentum imparted by the alpha decay [4]. While the former process yields predominantly singly charged ions, the latter also leads to substantially more highly charged ions [4]. Within this project, laser ablated thorium-232 ions were trapped in a linear Paul trap [3], a recoil ion source providing electrostatically decelerated Th ions [4] has been built and commissioned, and an apparatus for systematic studies of the laser-ablation production of atomic and molecular Th ions has been developed.
Laser ablation and in-flight reactions are used for the production of molecular thorium ions. Molecules including ThF [5] are of interest in the search for scalar dark matter [6] and could be used as quantum sensors to search for CP violations [7]. For this, further experiments are aimed at investigating the laser ablation behavior of different thorium isotopes in salt-based form and the formation and delivery of different thorium molecules from chemically different Th samples.

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Session Classification: Plenary Session 9