

# Nuclear Hyperfine Mixing and Laser Excitation of H-like $^{229}\text{Th}^{89+}$

Wednesday, 1 June 2022 14:40 (5 minutes)

Continuation of E142.

The “nuclear clock” isomeric state  $^{229}\text{-Thorium}$  with its exceptional low excitation energy of around 8.3 eV is in the research focus of many laboratories worldwide.

At GSI, an alternative approach to the physics of  $^{229}\text{-Th}$  is under development: We propose to investigate and utilize a phenomenon that is unique to very highly charged  $^{229}\text{Th}$  such as one-electron  $^{229}\text{Th}^{89+}$ . In high thorium charge states, in addition to the ordinary hyperfine structure, the very strong magnetic field mediates a mixing of the  $F = 2$  levels of ground state (g.s.) and isomeric state (i.s.). The mixing results in a drastical change of the nuclear lifetime which decreases drastically by 5-6 orders of magnitude, from a few hours down to a few 10 ms. The vastly accelerated decay e.g. in  $^{229}\text{Th}^{89+}$  implies that the excitation probability with a laser and the detection of fluorescence light are each enhanced by these 5-6 orders of magnitude.

It is proposed to investigate nuclear hyperfine mixing using laser spectroscopy at the storage ring ESR. In a first run (E142) and also in a further experiment that aims at laser excitation of the HF-splitting in H-like  $^{208}\text{-Bi}$  (E128), substantial progress towards laser experiments with artificially synthesized radioisotopes was achieved and the general feasibility of such low-intensity laser experiments was demonstrated. Furthermore, production, separation and storage of a few times  $10^4$   $^{229}\text{Th}^{89+}$  was achieved, and an upgrade path for future experiments identified. Yet, the 2022 experiment suffered from the availability of stable, intense primary beam and a long list of technical issues from the accelerator side, such that only a small fraction (2 to 3 days) of the allotted beamtime (~2 weeks) could be used to search for the  $^{229}\text{-Th}$  resonance.

It is proposed to continue E142, and to search for the two laser excitation pathways in hyperfine mixed  $^{229}\text{Th}^{89+}$ .

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**Session Classification:** ESR