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Nuclear Hyperfine Mixing and Laser Excitation of H-like 229Th89+

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Continuation of E142.

The “nuclear clock” isomeric state 229-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-Th is under development: We propose to investigate and utilize a phenomenon that is unique to very highly charged 229Th such as one-electron 229Th89+. 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 229Th89+ implies that the excitation probability with a laser and the detection of fluorescense 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 aimes at laser excitation of the HF-splitting in H-like 208-Bi (E128), substantial progress towards laser experiments with artificially synthesized radioisotopes was achieved and the general feasibility of of such low-intesity laser experiments was demonstrated. Furthermore, production, separaion and storage of a few times 10^4 229Th89+ was achieved,and an upgrade path for future experiments identified. Yet, the 20222 experiment suffered from the availabilty of stable, intense primary beam and a long list of technical issues from the accelarator 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-Th resonance.
It is proposed to continue E142, and to search for the two laser excitation pathways in hyperfine mixed 229Th89+.

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