Towards in-gas-jet studies of $^{229\,\mathrm{m}}\mathrm{Th}^{+}$

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Abstract

Short half-lives, low production rates and the need to produce them by fusion-evaporation reactions all complicate laser spectroscopy studies of (trans)actinides. The In-Gas Laser Ionization and Spectroscopy (IGLIS) technique has been succesfully employed in studies on short-lived actinides (see for instance [1, 2]). The addition of a convergent-divergent (de Laval) nozzle to create a cold hypersonic gas jet combines efficiency with sub-GHz spectral resolution. The new generation of nozzles with a Mach number of 8 enables laser spectroscopy studies of actinides with spectral resolutions around 200 MHz [3].

The light actinide ^{229}Th and its nuclear clock isomer have attracted significant attention in the last years. A remarkable feature is the suggested short half-life (< 10 ms) of the isomer in its, not-yet observed, singly charged state [4]. We report on the design of a fast-extraction gas cell (evacuation time of ~ 1 ms) and tailor-made recoil ion sources of ^{233}U prepared by TU Vienna and JGU Mainz which are installed inside the gas cell to provide the isomeric thorium ions. A new set of de Laval nozzles was designed and characterized to operate under the required low-stagnation-pressure conditions of the recoil sources as well as for spectroscopy studies of (trans)actinides in the JetRIS experiment at GSI [5]. A level search above the second ionization potential of thorium revealed several auto-ionizing states which are used to improve laser ionization efficiency for future in-gas-jet laser spectroscopy studies of $^{229\mathrm{m}}\mathrm{Th}^{+}$.

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