Measurement of the orbital electron capture and the β^+ decay of hydrogen-like ions at the Experimental Storage Ring of GSI

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The Experimental Storage Ring (ESR) at the GSI Helmholtzzentrum in Darmstadt is still the only facility where nuclear β decays of stored, highly-charged ions have been addressed and, in particular, two-body β decays, such as orbital electron capture (EC) and bound-state β^- (β_b) decay. There, in the final state only a "monoenergetic" electron (anti) neutrino and a recoiling daughter ion do emerge, intertwined by momentum- and energy-conservation. In an experiment, conducted a few years ago at the ESR, periodic time-modulations, superimposed on the expected exponential decay, have been found in the EC decay of both, hydrogen-like $^{140}Pr^{58+}$ and $^{142}Pm^{60+}$ ions. Now, we measured for a second time the EC decay of hydrogen-like $^{142}Pm^{60+}$ ions by using as Schottky-noise detectors the previously employed capacitive pick-up as well as a newly designed 245 MHz resonator cavity with much improved sensitivity and time resolution. This detector provides for each single EC decay un-ambiguously the exact time of the decay and, moreover, the full kinematics of the recoiling daughter ion since the moment of its "birth".

The new results corroborate for both detectors exactly our previous findings of a statistically significant modulation with a period near to 7 seconds, though with distinctly smaller amplitude. The latter observation is not yet understood. Also the β^+ decays have been analyzed which do not show any significant modulation near to a period of 7 seconds. The confirmed observation that periodic modulations are appearing in the two-body EC decay, where "monoenergetic" electron neutrinos are generated, while being absent in the three-body β^+ decay with a broad neutrino spectrum, could point to weak interaction and, in particular, to the peculiar features of two-body weak decays as the origin of the oscillations. The data furthermore suggest that interference terms are present in the EC decay, whilst the emerging neutrinos are not directly observed.