Radioactive decays of highly-charged ions

Yuri A. Litvinov[1]

[1] GSI Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt, Germany

E-mail: Y.Litvinov@gsi.de

High atomic charge states can significantly influence nuclear decay rates. An obvious example is the electron capture (EC) decay probability, which depends strongly on the number of bound electrons. One of the straightforward motivations for studying radioactive decays of highly charged ions (HCI) is that stellar nucleosynthesis proceeds at high temperatures, where the involved atoms are highly ionized. Furthermore, HCIs offer the possibility to perform basic investigations of the decay phenomena under clean conditions: The decaying nuclei having, e.g., only a single bound electron, represent themselves well-defined quantum-mechanical systems, in which all interactions with other electrons are excluded, and thus the complicated corrections due to shake-off effects, electron screening etc. can be removed.

Largest modifications of nuclear half-lives with respect to neutral atoms were observed in beta decay of fully ionized nuclei. Presently, the ion-storage ring ESR at GSI in Darmstadt is the only tool in the world for addressing radioactive decays of HCIs. There, the radionuclides produced at high kinetic energies as HCIs and purified from unwanted contaminants can be stored in the cooler-storage ring ESR. Due to the ultra-high vacuum of about 10^{-10} mbar, the high atomic charge states of stored ions can be preserved for extensive periods of time (minutes, hours). The decay characteristics of electron cooled stored HCIs can accurately be measured by employing the highly sensitive non-destructive time-resolved Schottky spectrometry technique.

Recent experiments with stored exotic nuclei that have been performed at the ESR will be discussed in this contribution. A particular emphasis will be given to two-body decays, namely bound-state beta decay and orbital electron capture.

As an outlook, the perspectives of future experiments with HCIs at existing storage ring facilities (ESR in Darmstadt and CSRe in Lanzhou) as well as at the planned facilities (TSR@ISOLDE, FAIR, HIAF, RI-RING) will be outlined.