Decay of proton-rich isotopes – Experimental approaches

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The binding of the protons and neutrons of the atomic nucleus is governed, in a first approximation, by the Bethe-Weizsäker macroscopic formula that gives the global shape of the so-called "valley of stability". For isotopes with an excess of protons, the main decay modes are the β^+ and electron capture processes. When going further from stability the decay energy Q_{EC} increases while the proton separation S_P decreases, opening the β-delayed proton emission channel. For more exotic nuclei, several protons can be emitted from states populated by the β decay. The detection of emitted protons is a very efficient tool to perform the decay spectroscopy of these exotic nuclei. It allows to address a wide range of topics such as nuclear base properties (half-lives, masses,…), nuclear structure (beta decay strength distribution, decay schemes, isospin mixing…), astrophysical processes (mainly rp-process) and even fundamental studies of the weak interaction.
When reaching the proton "drip-line", the nuclear interaction is not any more able to bind the proton(s) in excess. Nevertheless, 1 proton (for odd-Z nuclei) or 2 protons (for even-Z nuclei) can be trapped inside the nucleus for a short time due to the Coulomb and centrifugal barrier (and the pairing effect for even-Z nuclei). This gives rise to the 1- and 2-proton radioactivity processes.

The lecture will propose an introduction to the decay processes of proton-rich isotopes. It will mainly focus on experimental aspects, and to a large extend it should be complementary to the theoretical lecture from L.V. Grigorenko.
A general discussion will present the main technical aspects of the production of the exotic nuclei, and the basic experimental approaches to measure their decay modes.
Then typical experiments will be described, in order to illustrate various physics questions that can be addressed by mean of the β-delayed proton(s) emission studies. A part of the lecture will be especially dedicated to the experimental works dedicated to the 1- and 2-proton radioactivity.
These topics will be a good opportunity to present recent developments of the experimental techniques needed for current and future decay studies.

Suggested references (reviews):

- B. Blank and M.J.G. Borge, **Nuclear structure at the proton drip line: Advances with nuclear decay studies**, *Progress in Particle and Nuclear Physics* 60 (2008) 403–483
- M. Pfützner, L.V. Grigorenko, M. Karny, K. Riisager, **Radioactive decays at limits of nuclear stability**, *Review of Modern Physics* 84 (2012) 567