Liquid scintillation counting: A valuable tool to determine half-lives

Karsten Kossert [1)], Marcell Péter Takács [1)], Ole Nähle[1)]

1) Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, 38116 Braunschweig, Germany

Corresponding author's e-mail: karsten.kossert@ptb.de

In the past two decades, the radionuclide metrology group at PTB carried out a number of half-life determinations (see Figure 1) using liquid scintillation counting (LSC). The half-lives, which were often determined in collaboration with other institutions, range from a few ten nanoseconds (e.g. 86 keV level of ^{233}Pa) to several billion years (e.g. ^{87}Rb). This review aims to give an overview on the various half-life determination techniques that were used, and to demonstrate the great potential of LSC as an experimental tool for such measurements.

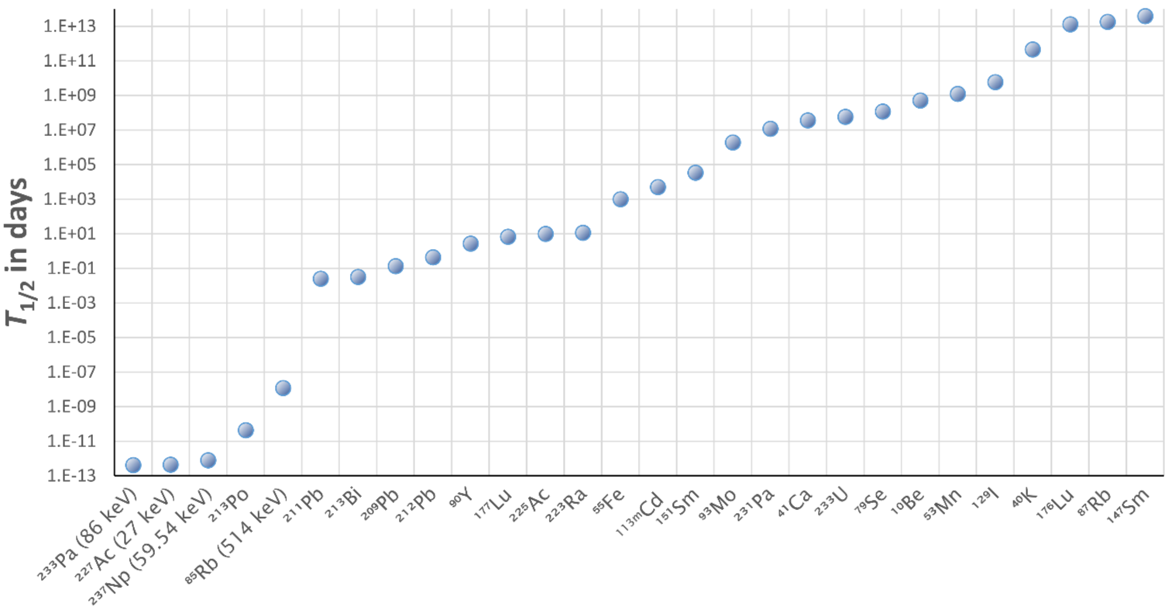

Figure 1: Half-lives that were determined at PTB using LSC since 2003.

Shorter half-lives can simply be determined by means of long-term measurements following the exponential decay. Here, the triple-to-double coincidence ratio method (TDCR) proved its worth since it gives additional information on the sample stability and counter efficiency which may change over time. Hence, the TDCR method can provide valuable information which is usually not accessible when using other methods.

Very long half-lives (> 100 years) are typically determined by a combination of primary activity standardization and a determination of the number of nuclei which can be obtained from mass spectrometry. These measurements can be very challenging, since the activities to be measured are very low when measuring very long-lived radionuclides.

Moreover, we have demonstrated that by combining an LS counter with a gamma detector and a full digital data acquisition, the measurement of very short (level) half-lives becomes feasible as well. By adopting an offline data analysis approach, one can study the time relation between the detector signals in more detail, and half-lives in the order of a few ten nanoseconds can be derived.

Finally, we propose repetitive primary activity measurements as an additional possibility to determine half-lives. This method was applied to determine the half-life of ^{55}Fe using custom-built TDCR counters. The advantage of the proposed method is that it is less sensitive to potential long-term instability of LS samples.