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Measuring the half-life of Po-215 by low-level liquid scintillation counting

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The radioactive isotope of 215Po is a part of the decay chain historically known as the actinium series, which starts with the naturally occurring 235U and ends in the stable isotope of 207Pb. When neglecting 215At, which is only present in insignificant amounts, 215Po is the progeny with the shortest half-life (of about 1.8 ms) in the decay chain.

Due to the limited time scale, a simple half-life determination by measuring the diminishing activity of a chemically separated sample as function of time is not feasible. Instead, one has to apply the so-called delayed coincidence method, in which the distribution of the lifetimes of individual 215Po nuclei is measured. In previous experiments, this was achieved by e.g. placing a thin 227Ac sample in between two silicone surface barrier detectors and measuring the elapsed time between the alpha decay of 219Rn and the following alpha decay of 215Po itself.

In this paper, we present an alternative approach using liquid scintillation counting (LSC) in combination with digital data acquisition and offline data analysis. The use of LSC simplifies sample preparation and handling but provides limited energy resolution compared to silicone surface barrier detectors. However, due to the fact that all other members of the actinium series have half-lives which are several magnitudes longer than the one of 215Po, the discrimination between different alpha energies is not strictly necessary. By limiting the source activity so that the average time gap between two alpha decays becomes considerably longer than the half-life of 215Po, an indirect selection of alpha events can be achieved. On a timescale equivalent to 10-15 half-lives of 215Po, the time difference distribution of event pairs related to the same 215Po nucleus would result in Poisson statistics, whereas uncorrelated alpha decays observed on the same time scale would contribute to a constant background.

For our experiment, a single LS sample was prepared from aqueous solution of 227Ac in standard 20 mL polyethylene vials using Ultima Gold AB scintillator. The initial 227Ac activity was approximately 0.5 Bq. The vial was then measured in a custom-built triple-to-double coincidence ratio (TDCR) counter, equipped with 3 photomultiplier tubes (PMT). During the measurement all observed events were recorded in list-mode format by a fast digitizer. The half-life determination took place offline by studying the time difference distribution of triple coincidence events, where all PMTs fired within 40 ns.

The measurement is still ongoing, but the obtained preliminary half-life of 1.779 (7) ms (based on data taken over a period of 40 days) is in good agreement with the currently recommended value of 1.781 (4) ms for 215Po. This shows the feasibility of the above-described approach. Further details of the measurement and the final result will be presented at the conference.

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