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Simultaneous double alpha decay of Ra-224

In nature several decays occur during which two particles of the same nature are emitted simultaneously, such as double beta decay in which two electrons are emitted together with two antineutrinos or double gamma decay. In addition, close to the proton and neutron drip lines nuclear decays with simultaneous emission of two protons and two neutrons have been observed. Simultaneous double alpha decay has been predicted since the 1980s [1], but has never been observed due to its expected small branching ratio.

This simultaneous double alpha decay is considered to occur in two different modes particularly in heavy nuclei. Either, via tunnelling of a Be-8 nucleus before splitting into two alpha particles [2], or, via the simultaneous formation of two alpha particles, which then tunnel the barrier in opposite directions [3]. Recent theoretical studies [3] have shown that the back-to-back decay is favoured by more than 10 orders of magnitude compared to the Be-8-like double alpha decay mode. These microscopic energy density functional calculations predict the highest branching ratios for the back-to-back double alpha decay to occur around Ra-224, with branching in the order of 10^-9.

A new experiment has been set up by combining the FRS Ion Catcher at GSI [4] with a double-sided silicon strip detector (DSSSD) decay setup [5]. Measurements have been performed utilizing two Th-228 recoil sources with a total activity of 36 kBq mounted inside the cryogenic stopping cell (CSC). Daughter nuclei were thermalized in ultrapure helium gas and extracted from the cell to be filtered using a system of radio-frequency quadrupoles (RFQ), resulting in a pure ion beam of Ra-224. The Ra-224 ions were then implanted on a 10 µg/cm2 carbon foil sandwiched between the two DSSSD. The two detectors were then used to record the position, time and energy of each alpha particle emitted from the implanted Ra-224 allowing back-to-back reconstruction. Since the experiment has been performed using radioactive sources instead of an online radioactive beam, continuous data-taking over a period of about four months has been performed. In total about 10^10 alpha particles following the decay of Ra-224 have been recorded.

This contribution will describe the design and setup of the experiment and conclude with preliminary results from a first experimental run searching for the simultaneous double alpha decay in Ra-224.

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