^{19}Mg Two-Proton Decay Lifetime: A New Application of the Recoil Distance Method

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Two-proton decay lifetime measurements of light even-Z nuclei beyond the proton drip line exemplify the struggle of spectroscopy at the limits of existence. As the interplay of the Coulomb and centrifugal barriers influence the emission of unbound protons, precise lifetime measurements of these exotic species hold promise to shed light on the nuclear wave function and valence proton correlations. An adaptation of the Recoil Distance Method has therefore been developed at the National Superconducting Cyclotron Laboratory (NSCL) for lifetime studies of short-lived proton-emitting nuclei. This variant of the Köln/NSCL plunger technique utilizes a thin silicon double-sided strip detector positioned downstream of the reaction target to measure the energy loss ratio of the two-proton decay precursor and heavy-ion decay residue.

The pioneering measurement investigated the ^{19}Mg ground state two-proton decay lifetime. The ratio of ^{19}Mg and ^{17}Ne energy losses at various target-detector distances was measured in coincidence with ^{17}Ne decay residues in the S800 Magnetic Spectrograph. Simulated heavy-ion lineshapes generated over a broad range of lifetimes were fit to the energy loss signatures. The best-fit lifetime was found to increase from 0.39(9) ps to 2.44(54) ps as a function of an increasing prompt production (from reactions rather than two-proton decays) of ^{17}Ne. These results are significantly shorter than the previously reported lifetime of 5.8(22) ps [1] and three-body decay model predictions [2] and are indicative of the challenge in understanding how valence proton orbital configurations impact particle stability beyond the drip line. An overview of this sensitive experimental technique for picosecond-ordered proton-decay lifetime measurements will be presented.

References

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