Measurement of analog-antianalog isospin mixing in ^{47}K β decay

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Many isotopes undergo β minus decay to states of same spin I and parity π, but sometimes decays to the isobaric analog state are energetically forbidden; in these cases, the Gamow-Teller operator dominates, while the Fermi operator linking isobaric analog states is only allowed if some low-lying final state of the same I^π is mixed by an isospin-breaking interaction with the excited isobaric analog. We see such isospin breaking in an $I^\pi = 1/2^+$ state in the ^{47}Ca nucleus 80% fed by the β decay of ^{47}K. Interference between Gamow-Teller and isospin-suppressed Fermi amplitudes produces an asymmetry of the progeny recoil direction with respect to the initial nuclear spin, which we measured with TRIUMF's Neutral Atom Trap for β decay (TRINAT).

Since ^{47}Ca and ^{47}K are near closed shells, the single known ^{47}Ca $1/2^+$ state may contain much of the anti-analog configuration, and is predicted to have a relatively large Coulomb mixing matrix element with the analog. Sensitivity to time reversal-odd parity-even inherently isovector *N-N* interactions through a β-ν-spin correlation is thought to be enhanced in these systems. This is because the small amount of time reversal is referenced to Coulomb rather than strong interactions, which motivates our measurement of isospin breaking in ^{47}K decay.

Using 6×10^6 s^{-1} mass-separated ^{47}K delivered from the TRIUMF-ISAC isotope separator online facility, we trapped on average 500–1000 ^{47}K atoms during the data-taking time. We alternated 2.9 ms trapping with 1.1 ms optical pumping, during which we made the polarized β-decay measurements. The fraction of nuclear polarization achieved for the decaying ^{47}K atoms was $P = \langle I_z \rangle / I = 0.96(4)$. An

electric field collected ^{47}Ca ions produced in ^{47}K β^- decay to an MCP and the shake-off electron(s) on another MCP detector (see Fig. 1); this coincidence condition minimizes backgrounds and decays not originating from trapped atoms, and integrates over all β and ν momenta. The right panel of Fig. 1 shows the observed position spectrum of the recoil ions along the polarization axis (top) and resulting asymmetry (bottom) with this coincidence. The results clearly show a non-zero ratio of Fermi to Gamow-Teller matrix elements, $y \equiv g_V M_F / g_A M_{GT}$. Although not as clean as coincidences with the shake-off

e^- detector, position asymmetries with coincidences in the β-telescopes are also sensitive to y , albeit with larger uncertainties (less events with an increased sensitivity to the electric field and relevant branching ratio). When averaging the two measurements, our final result is y = 0.098(37) . The Gamow-Teller component has been measured to be $g_A M_{GT} = 0.305$ [1], giving $|M_F| = 0.030(11)$ which in turn

leads to a Coulomb matrix element $|H_C|$=101(37) keV. This is a relatively large value, which is in reasonable agreement with the 160 keV predicted by Ref. [2]

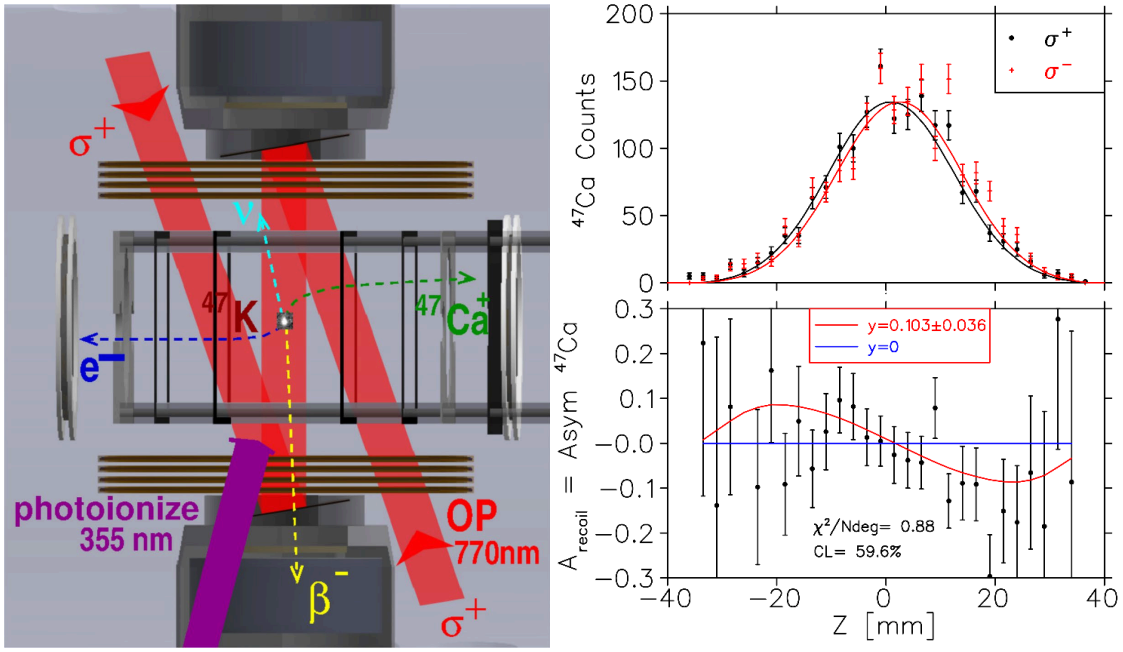

FIG.1. Left: schematic of TRINAT's detection chamber depicting the optical pumping (OP) and photoionization beams, hoops to generate the 650 V/cm field, the two MCP detectors, and the E-ΔE β telescopes. Top-right: distribution of $^{47}Ca^{+2,\ldots,7}$ along the polarization axis in coincidence with shake-off e^- for the two polarizations. Bottom-right: the asymmetry of these distributions A_{recoil}, i.e., the difference divided by the sum of the top distributions. The nonzero asymmetry scales with $y \equiv g_V M_F / g_A M_{GT}$ and directly implies a nonzero Fermi contribution.

The interested reader can find more details in B. Kootte *et al.*, Analog-antianalog isospin mixing in ^{47}K β^- decay, Phys. Rev. C **109**, L052501 (2024).

[1] P. Choudhary, A. Kumar, P. C. Srivastava, and T. Suzuki, Phys. Rev. C **103**, 064325 (2021).
[2] N. Auerbach and M.-L. Bui, Nucl. Phys. **A1027**, 122521 (2022).