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Half-Lives of ^{46}V, ^{50}Mn, and ^{54}Co†

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The nuclides ^{46}V, ^{50}Mn, and ^{54}Co were formed via the (p,n) reaction at $E_p = 10$ MeV and half-lives were measured by observing β rays in a plastic scintillator. Values obtained were 425.3 ± 2.0, 285.1 ± 0.9, and 193.1 ± 0.8 msec, respectively. The results agree with previous work within errors and thus confirm the systematic behavior of these $0^+ \rightarrow 0^+$ superallowed Fermi β decays.

The half-lives of several nuclides decaying by superallowed $0^+ \rightarrow 0^+$ β-ray transitions were measured[1] recently at this laboratory, the main motivation being a $4.6 \pm 1.7\%$ discrepancy that had been noted[2] in the ft values of the mass-34 mirror decays. Of the seven known $T_z = 0$ cases the half-lives of four that could be reached by (t, n) reactions, i.e. ^{26m}Al, ^{34}Cl, ^{38m}K, and ^{42}Sc, were measured. From the results the mass-34 discrepancy was reduced to $2.5 \pm 1.7\%$ and the half-life obtained for ^{38m}K was in better agreement with the systematics.

For the remaining three $T_z = 0$ nuclides, ^{46}V, ^{50}Mn, and ^{54}Co, half-life values with stated errors of <1% were reported[3,4] in 1965 by a group from Harwell; only in the case of ^{46}V is there another measurement[5] of comparable accuracy. In the meantime the Harwell group has reanalyzed[6] their ^{26m}Al data[3] and has shown that systematic effects in the earlier analysis required corrections considerably larger than the quoted errors. Also, it may be noted their result[3] for ^{34}Cl differs from the recent Brookhaven value[1] by 2.0%, or more than 4 standard deviations. The importance of ^{46}V, ^{50}Mn, and ^{54}Co to the systematics of superallowed β decay requires that their half-lives be rechecked, particularly in view of the questions raised by the foregoing discussion.

All three activities were made via the (p, n) reaction using 10-MeV protons from one of the Brookhaven MP tandem Van de Graaff accelerators. Targets consisted of 0.013-mm-thick Ti foil, enriched ^{50}Cr 150-μg/cm^2 thick on Au, and enriched ^{54}Fe 460-μg/cm^2 thick on Au. An NE102 plastic scintillator 5-cm diam × 2.5-cm thick was used to detect the β rays. Experimental procedures and methods of extracting half-lives were similar to those of the earlier measurements.[1] The results are displayed in Table I together with previously reported values; it is seen that the present and previous work agree within the errors. Greater confidence may therefore be placed in the systematic behavior of half-lives for this series of superallowed Fermi β decays and only minor adjustments need be made in the ft values[7]

TABLE I. Experimental half-lives.

Decaying nucleus	Present results (msec)	Previous results (msec)
^{46}V	425.3 ± 2.0	425.9 ± 0.8 [a]
		424 ± 2 [b]
^{50}Mn	285.1 ± 0.9	285.7 ± 0.6 [a]
^{54}Co	193.1 ± 0.8	193.7 ± 1.0 [c]

[a] Reference 4.
[b] Reference 5.
[c] Reference 3.

for these three cases as a result of the present work.

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Linear-Polarization Measurements of the Gamma-Ray Transitions in ^{20}F†

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Linear-polarization and angular-distribution measurements are reported for the γ rays from the decay of the 636-, 823-, 984-, 1057-, 1309-, and 2044-keV levels in ^{20}F. Using our data, in addition to that of previous workers, the levels at 984 and 1309 keV were found to have negative parity, as opposed to the previous assumption of positive parity. Spins and parities of the other levels are discussed, as well as the mixing ratios of the decay γ rays.

I. INTRODUCTION

The odd-odd nucleus ^{20}F has been treated with detailed shell-model calculations using a number of different Hamiltonians,[1,2] and as a deformed core, to which the odd neutron and odd proton are coupled.[3] Four odd-parity states below 2 MeV are predicted by a model which couples a $p_{1/2}$ and a $p_{3/2}$ proton hole to the ground state of ^{21}Ne.[4] All of these calculations suffer from a lack of experimental information about ^{20}F, even though the nucleus has been the subject of many experimental investigations in the last several years.[5,6] In particular, the spins and parities of the levels at excitation energies of 823, 984, and 1309 keV are not known. The levels at 984 and 1309 keV are good candidates for the predicted odd-parity states, since there are four states below 2 MeV that are not accounted for by shell-model calculations. These states are the states at 984, 1309, 1840, and 1971 keV. Up to the present time linear-polarization measurements on the γ-ray decay of these states have not been possible, as NaI polarimeters do not have the resolution necessary to separate the decay γ rays from each other. The development of high-resolution polarimeters has made these polarization measurements possible. A measurement of the linear polarizations of the γ-ray transitions from the low-lying levels can give information about the spins and parities of these levels, as well as the mixing ratio of the transitions themselves. These measurements were undertaken to obtain additional information about these low-lying levels.

II. EXPERIMENTAL

The ^{19}F$(d, p)^{20}$F reaction was used to populate the levels in ^{20}F. A thin CaF_2 target was bombarded with deutron beams of 0.9, 1.1, and 1.2 MeV. It was found that a deutron energy of 1.2 MeV gave slightly better alignment to the states in ^{20}F; therefore all the measurements discussed were carried out at this energy. The angular distributions and the linear polarizations of the γ transitions from the levels in ^{20}F were measured