cidence of this order of magnitude with the observed lifetime of a neutral meson decaying into two photons could be accidental; still, it suggests the possibility of some connection between the apparent lifetime of unstable particles and a finite duration of the interaction between the particles which take part in the production and decay processes.

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Mass of K^{40}†

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THE determination of a decay scheme for K^{40} depends upon the magnitudes of the gamma- and beta-ray energies. In the past, a number of somewhat widely varying values have been reported. These varying values lead to an uncertainty in the decay scheme. Recent experiments suggest that a decay scheme having K^{40} decay to Ca^{40} by a beta-decay, and to A^{40} by a K capture followed by a gamma-ray emission is correct. In order to substantiate this conclusion, I have measured the masses of K^{40}, A^{40}, and Ca^{40} employing a double-focusing mass spectrometer.[1] The total energy differences between the three nuclides, found from the masses, can be compared with the beta- and gamma-ray energies.

A sample of potassium containing 7.74 percent of K^{40}, obtained from the Electromagnetic Separation Plant in Oak Ridge, Tennessee, on allocation from the Isotope Division, U. S. Atomic Energy Commission, was used as a source of potassium ions. In earlier determinations of the masses of A^{40} and Ca^{40}, the hydrocarbon fragment $(C^{12})_3(H^1)_4$ was used as a comparison peak. This it not a good fragment to use because of the large $(C^{12})_2C^{13}(H^1)_3$ unresolved satellite. While correction has been made for this, it is a possible source of error. In the present work, this difficulty has been eliminated by employing the fragment $(C^{12})_2O^{16}$ from acetic acid. Normal calcium metal was used as a source of Ca^{40} ions.

In this experiment, a run consisted of eight C_2O-A^{40} traces, ten C_2O-K^{40} traces, and then eight more C_2O-A^{40} traces. From each run, the C_2O-K^{40} result was compared with an average of the two C_2O-A^{40} results to obtain the mass difference of the $K^{40}-A^{40}$ doublet. In a similar manner, the doublet $Ca^{40}-A^{40}$ was determined. This method had to be employed because the K^{40}, A^{40}, and Ca^{40} ion peaks were not resolved in the mass spectrometer.

In the case of the potassium runs, a small correction had to be made because of the unresolved residual A^{40} peak, while in the calcium runs, because of the much larger beam current, no correction for residual A^{40} was necessary. A small calcium impurity found in the spectroscopic analysis of the K^{40} sample could cause a low $K^{40}-A^{40}$ result. Because of peak shape consistencies, this error was believed to be less than 10 percent of the $K^{40}-A^{40}$ difference.

The weighted averages of four calcium-argon runs for the doublets C_2O-A^{40}, C_2O-Ca^{40}, and $Ca^{40}-A^{40}$ yield 32.756±0.010, 32.557±0.009, and 0.201±0.015 millimass units, respectively. The averages of five potassium-argon runs for the doublets C_2O-A^{40}, C_2O-K^{40}, and $K^{40}-A^{40}$ yield 32.735±0.024, 31.140±0.081, and 1.595±0.071 mMU, respectively. The masses of the three nuclides may be calculated using C^{12} to be 12.003842±4[1] and O^{16} to be exactly 16 atomic mass units. The masses of K^{40}, Ca^{40}, and A^{40} are then 39.97654±8, 39.975127±11, and 39.974940±15 aMU, respectively. The argon mass is determined from a weighted average of all the argon data. The disagreement between the Ca^{40} and A^{40} masses reported here and those previously reported[2] may be attributed to several improvements in the instrument and to the elimination of the large C^{13} correction, necessary in the previous work.

From the masses, the total energies for the decay of K^{40} to Ca^{40} and A^{40} are 1.30±0.07 and 1.49±0.07 Mev, respectively. The energy released in the decay to Ca^{40} agrees well with the most recent beta end-point determinations which gave energies of 1.40±0.03,[3] 1.36±0.05,[4] 1.28±0.03,[5] and 1.325±0.015[6] Mev. The result disagrees with earlier determinations which in several cases gave values higher than 1.45 Mev.[7,8] Two of the earlier determinations which gave lower values were 1.3[9] and 1.35[10] Mev. Several recent determinations of the gamma-ray energy for the K^{40} decay gave values of 1.47±0.03,[11] 1.462±0.01,[12] and 1.459±0.007[13] Mev. Because the gamma-ray energy is greater than the total energy available in the decay to Ca^{40}, it must be associated with the decay to A^{40}, as is true in the presently accepted decay scheme.

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Angular Distribution of Neutrons of the *d-d* Reaction

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WE have recently measured the angular distribution of neutrons from the $H^2(d,n)He^3$ reaction using 50-kev incident deuterons. The deuteron beam was furnished by a radiofrequency ion source of the type described by Moak *et al.*[1] and was focused on a deuterium target prepared by bombarding to saturation a thin copper plate. The diameter of the deuterium spot on the copper plate was approximately 3.5 mm.

Seven Ilford C-2 nuclear plates with emulsions 100 microns thick were positioned radially around the target at laboratory angles of 15°, 30°, 75°, 90°, 105°, 120°, and 135° with the deuteron beam. The plates were exposed to the neutron flux for forty hours. To discriminate against proton-recoil tracks caused by neutrons scattered on the plates by surrounding material, only those tracks whose visible horizontal projection was equal to or greater than 40 microns and whose angle with the neutron beam was equal to or less than $\sin^{-1} 0.4$ were counted. The entire thickness of the emulsion was examined for each field of view. Five traverses, each 2 cm long, which were made across an unexposed background plate revealed only one acceptable track; consequently, background corrections were not considered necessary.

It is customary in angular distribution experiments to analyze the results so as to determine the values of asymmetry coefficients. At low deuteron bombarding energies, this amounts to selecting that value of A in the expression $N'(\theta')=N'(90°)(1+A\cos^2\theta')$, where primed quantities are in center-of-mass coordinates, which

TABLE I. The number of recoil protons $N(\theta)$ at different laboratory angles θ, with transformation to center-of-mass coordinates θ'. $g(\theta)$ is the transformation factor connecting $N(\theta)$ and $N'(\theta')$.

θ	θ'	$N(\theta)$	$g(\theta)$	$N'(\theta')$
15°	15.7°	423	0.918	388
30°	31.4°	398	0.925	368
75°	77.8°	343	0.977	335
90°	92.9°	256	1.000	256
105°	107.8°	340	1.024	348
120°	122.5°	350	1.047	366
135°	137.0°	366	1.068	391