excitation energy (34.4 kev) as the one under discussion.[1] Its half-life of 51.5 min. and the $K:L$ conversion ratio, however, point to its assignment to the next lower transition order.

* Present address: Radiation Laboratory, University of California, Berkeley, California.

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The Intermediate Cosine Coupling in Molecular Beams

WILLIAM A. NIERENBERG
University of California, Berkeley, California
October 26, 1950

COSINE coupling between nuclear spin, **I**, and rotational angular momentum, **J**, in molecules, is now a well established phenomenon.[1-9] It is particularly important for $I=\frac{1}{2}$, where it is the only angular dependent interaction possible except for the very small spin-spin interaction. The width of the molecular beam resonance line in fluorine in LiF has been explained with this hypothesis for strong enough magnetic fields to break this coupling.[2] Unfortunately, in the zero-field limit, where the spectrum has been discussed theoretically, the observations were obscured by experimental difficulties.

It has therefore been considered desirable to calculate the molecular beam line shape for diatomic molecules and large J for all values of the magnetic field so that experimental verification can be performed to nearly zero field for $I=\frac{1}{2}$. This calculation has been completed. The line shape is given by:

$$dN/dx=(w/2)^{\frac{1}{2}}(x/x_I)[\mathrm{erf}(x+x_I)-\mathrm{erf}|x-x_I|].$$

The notation of reference 2 is used $x=h a\nu/c$. Here ν is the radio-frequency, c is the coefficient of the $\mathbf{I}\cdot\mathbf{J}$ coupling in the Hamiltonian, $x_I=h a\nu_I/c$, where ν_I is the Larmor frequency of the uncoupled nucleus. $a=(h^2/8\pi^2KkT)^{\frac{1}{2}}$, where K is the moment of inertia of the molecule. x_I is therefore the correct measure of the coupling. For large values of the magnetic field $x_I\to\infty$ and the limiting value of dN/dx agrees with the result found previously. If $x_I\to 0$, we have the Zeeman effect and the limiting value of dN/dx for $x_I=0$ also agrees with the earlier results.

Figure 1 is the line shape for $x_I=1$. It is clear that the line

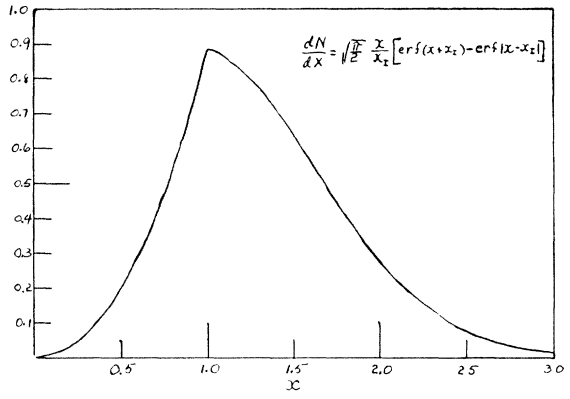

FIG. 1. Line shape for $x_I=1$.

shape has become highly asymmetric. The calculation ignored the transition probabilities, the quadrupole coupling of **J** to the other nucleus and the resolution of the apparatus. These effects can be estimated and can usually be ignored.

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Half-Life of Fe^{55} and Co^{60}

G. L. BROWNELL AND C. J. MALETSKOS
Radioactivity Center, Laboratory for Nuclear Science and Engineering, Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts*
October 23, 1950

THE half-life of Fe^{55} is listed in the 1948 Seaborg and Perlman table[1] as about 4 years, and this value is ascribed to a personal communication from Van Voorhis. As this entry is identical with that in the 1940 Livingood and Seaborg table,[2] it can be assumed that the measurements were made prior to this date. With the exception of the estimates made in the discovery paper of Livingood and Seaborg,[3] this value is the only published report which has been found on the half-life of Fe^{55}.

The original observation of the long-lived Co^{60} activity was made by Sampson, Ridenour, and Bleakney[4] in 1936. Livingood, Fairbrother, and Seaborg[5] in 1937 estimated the half-life to be greater than 1 year, and in the same year, Risser[6] measured the half-life as 2.0 ± 0.5 years. The value reported in the 1940 table[2] was 7.0 years based on unpublished work of Livingood and Seaborg. This value was later changed by Livingood and Seaborg[7] to 5.3 years, and the latter value appears in their 1948 table.[1]

Measurements have been made over a period of 18 months on the decay of a sample of Fe^{55} and Co^{60}. The iron sample was electroplated on a copper planchet from a sample of a cyclotron-produced stock solution of iron chloride which contained no Fe^{59}. The activity of this sample was 1.4×10^5 c.p.m. as measured with a G-M x-ray counter, and the true disintegration rate was perhaps one hundred times this value. The sample was sealed in an ionization chamber of about one liter active volume, and the chamber was filled to atmospheric pressure with tank argon from which water vapor had been removed by passing the gas rapidly through a liquid nitrogen trap. A brass plate controlled externally to the chamber covered the sample for background measurements. The cobalt sample was prepared by sealing about 15 microcuries of Co^{60} in the form of cobalt chloride in a glass vial. The activity was measured by placing the sample adjacent to the chamber. A radium standard was also measured to correct for small changes in the measuring equipment. The standard consisted of 25 microcuries of radium in the form of radium chloride sealed in a glass ampoule. The standard was measured in a manner similar to the cobalt sample. During and between measurements the standard was kept in a vertical position.

The ionization current was measured with a vibrating reed electrometer by the rate of charge method. Time measurements were read from an Esterline-Angus recording ammeter tape, and the voltage decrement was determined with a potentiometer and standard cell. The capacitance of the feed-back condenser in the vibrating reed electrometer was determined by comparison with calibrated resistors. The current produced in the chamber by the two samples and the radium standard was of the order of 1.5×10^{-13} amp., while the background current was 2.5×10^{-15} amp. At each determination five measurements were made with two positionings of each sample.

After a period of 12 months, the argon was removed and analyzed by passing slowly through a liquid nitrogen trap. No CO_2 was observed, but 0.5 percent of water vapor was found. This vapor could possibly have entered from gradual leakage into the chamber as a result of changes in atmospheric pressure or from insufficient outgassing of the short length of vacuum hose which allowed rotation of the background plate. It is very improbable that this amount of water vapor could produce oxidation of the iron sample. Although the O_2 content was not determined, the fact that no CO_2 was observed also makes oxidation very unlikely. The chamber was refilled with water-free argon, and the measurements continued.

After eighteen months of measurements, the chamber was disassembled. The appearance of the iron sample was the same as at assembly, and there was no evidence of oxidation. The portion of the copper planchet surrounding the iron sample was slightly tarnished, and this was attributed to the action of sulfur from

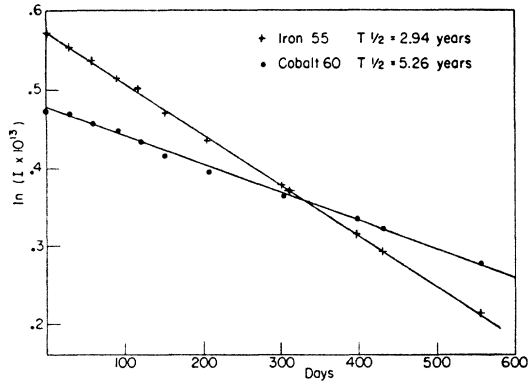

FIG. 1. Decay curves of Fe^{55} and Co^{60}.

the vacuum tubing. A search was made over the interior of the chamber for Fe^{55} activity with a G-M x-ray counter, and none was found.

The results of eleven determinations made over the 18-month period are shown on Fig. 1. The data are corrected for background and for small changes indicated by the radium standard (about two percent). The data have been analyzed by the method of least squares,[8] and the resultant values of half-lives of Fe^{55} and Co^{60}, and standard errors are shown in Table I. The 2.94-year

TABLE I. Half-lives of Fe^{55} and Co^{60}.

Isotope	Half-life	Standard error of half-life	Standard error per determination
Fe^{55}	2.94 years	0.98 percent	0.34 percent
Co^{60}	5.26 years	3.32 percent	0.65 percent

half-life of Fe^{55} is somewhat less than the presently accepted value of about 4 years, but the measured half-life of Co^{60}, 5.26 years, is in excellent agreement with the value of Livingood and Seaborg. The errors derived from this calculation provide a lower limit to the uncertainty in the half-life values, but since no gross instrumental errors have been detected, this error will be considered the total uncertainty in the half-life measurements. The larger standard error per determination for the Co^{60} results from inaccuracies in positioning of the external sample.

* This work has been assisted by the joint program of the ONR and AEC.
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Conversion Coefficient of the 35-Kev Gamma-Ray of Te^{125}

G. FRIEDLANDER, M. L. PERLMAN, AND G. SCHARFF-GOLDHABER
Chemistry Department and Physics Department, Brookhaven National Laboratory, Upton, Long Island, New York*
October 23, 1950

THE 58-day isomer[1] of Te^{125} is known to decay by a two-step transition.[2] A 109.7-kev transition which is at least 99 percent converted[1] is followed by a partially converted 35.4-kev gamma-ray. The K/L ratio for the 109.7-kev transition was measured by two groups[3,4] as 1.5 and 1.2; the L/M ratio has been reported[3] to be 3.5. The L and M conversion electrons of the 35.4-kev transition were observed in a spectrograph.[5] The K conversion electrons have escaped detection because of their low energies. By a coincidence method, the fraction of the 35.4-kev transitions internally converted (c) was estimated[2] as 0.80 to 0.85, the fraction of the transitions converted in the K shell (c_K) as 0.6 to 0.8. The unconverted 35.4-kev gamma-ray was observed by means of Geiger counters with critical fluorescence and absorption methods.[2]

With the use of a proportional counter and pulse-height analyzer[6] the 35.4-kev gamma-rays have now been measured directly from a pure Te^{125} source prepared by separation from Sb^{125}. Preliminary observations of these gamma-rays were made with an argon-filled counter. For the measurements, a 4-in. diameter brass counter was used which had a beryllium window and was filled to 3 atmos. with 97 percent krypton and 3 percent ethane. The observed pulse-height distribution with peaks representing the $K\alpha$- and $K\beta$-x-rays of tellurium and the 35-kev gamma-ray is shown in Fig. 1. An I^{126} source which gave a Te K x-ray intensity due to K-capture comparable to that from the Te^{125} had a negligible counting rate in the 35-kev region.

The relative peak heights for the K x-rays and the gamma-rays, after corrections for the x-ray fluorescence yield of tellurium, counter window transmission, counter efficiency, and peak position give a ratio of K holes to 35-kev gamma-rays of 17.2. From this ratio and from the previously measured[3,4] conversion fractions $c_{K109}=0.51$, $c_{L109}=0.38$, and $c_{M109}=0.11$ of the 109-kev gamma-ray one can calculate the unconverted fraction $c_{\gamma 35}$ and the K conversion fraction c_{k35} of the 35.4-kev transition provided an assumption is made about the ratio of c_{K35} to the total c_{35}. It will be seen that the value of $c_{\gamma 35}$ is not sensitive to the value assumed for this ratio. If c_{35} is assumed to be $1.1c_{K35'}$, then

$$1.1c_{K35}+c_{\gamma 35}=1=c_{109}=1.95c_{K109}. \quad (1)$$

From the measurements above,

$$c_{K35}+c_{K109}=17.2c_{\gamma 35}. \quad (2)$$

Combining (1) and (2) one obtains

$$c_{\gamma 35}=0.153c_{K109}=0.078,$$

and

$$c_{K35}=(1-c_{\gamma 35})/1.1=0.84.$$

If c_{35} is assumed to be $3c_{K35}$, then $c_{\gamma 35}=0.048$ and $c_{K35}=0.32$.

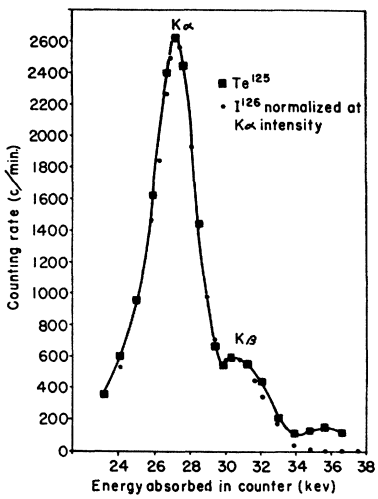

FIG. 1. Proportional counter pulse-height distribution for Te^{125} and I^{126} radiations.

These values and the approximate theoretical values[7,8] for various types of transitions are listed in Table I.

The present experiments establish that the unconverted fraction of the 35.4-kev transitions cannot exceed 0.08 ± 0.01 even if there is no conversion outside of the K shell. According to the theory of internal conversion, the transition therefore is not