The Quadrupole Moment Ratio of I^{129} and I^{127} from Pure Quadrupole Spectra*

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The pure quadrupole spectra for I^{129} and I^{127} have been observed in SnI_4 at 77°K and at 20°K. The nuclear quadrupole moment ratio has been determined to be $Q(I^{129})/Q(I^{127}) = 0.701213 \pm 0.000015$.

THE quadrupole moment ratio of long-lived fission I^{129} to stable I^{127} is known approximately from microwave measurements.[1] The frequencies of the direct quadrupole transitions for I^{129} and I^{127} in SnI_4 are reported in this paper. These measurements yield a more accurate value for the quadrupole moment ratio.

The compound selected for these measurements was SnI_4, since this substance gives very strong, sharp absorption lines, and it is easy to synthesize. A sample of SnI_4 was prepared from a solution containing about 40 mg of iodine as iodide. Although an isotopic analysis was not made on the sample, measurements on other similar samples consistently showed about 80 percent I^{129} and 20 percent I^{127}. The iodide was oxidized to iodine, extracted into CS_2, an excess of tin metal added, and the reaction allowed to go to completion by warming to about 50°C. This gave a solution of SnI_4 in CS_2 which was then evaporated to dryness. The solid product was sealed into a 2-mm diameter, thin-walled glass capillary. It is estimated that the capillary contained about 30 mg of I as SnI_4 (24 mg of I^{129} and 6 mg of I^{127}). The capillary fitted snugly into the spectrometer coil.

The spectrometer is a simple regenerative oscillator unit with a transmission line tuned circuit. The absorption lines were viewed on an oscillograph, and frequency measurements were made with a Gertsch FM-1B frequency meter. The Gertsch frequency meter contains a crystal oscillator, transfer oscillator, and interpolation oscillator. Improved accuracy was obtained by directly calibrating the interpolation oscillator at the settings used in each of the frequency measurements. A Signal Corps BC-221 frequency meter was used for this calibration. The FM-1B and BC-221 crystal oscillators

were also compared with radio station WWV. The measured frequencies and assignments are given in Table I. The frequencies are the average of several determinations, and subsequent calculations indicate that the precision is substantially better than the estimated accuracy of about 0.001 percent.

There are two nonequivalent iodine lattice positions in SnI_4, and this gives rise to a pair of lines for each transition indicated by lattice type A or B in Table I.

Calculations were made using equations given by Bersohn[2] for the energy levels E_m. The parameters determining a given E_m value are the z component of the quadrupole coupling, the nuclear spin (5/2 for I^{127} and 7/2 for I^{129}) and the asymmetry parameter $\eta = [(\partial E_x/\partial x) - (\partial E_y/\partial y)]/(\partial E_z/\partial z)$, where the derivatives are components of the field gradient tensor in the principal axis system. The calculations are summarized in Table II. The magnitude of the asymmetry parameter was evaluated from the frequency ratio of the two transitions observed for I^{129}. A frequency ratio of 1.5 for these transitions corresponds to $\eta = 0$, and within the accuracy of the frequency measurements this appears to be the case for the type B lattice positions (Table II). Further justification for $\eta = 0$ will be given below. Although Bersohn has given the levels by perturbation theory to fourth-order in η, a second-order treatment proved adequate for the type A lattice positions because of the small magnitude of η. The η-values and the corresponding transition frequencies for the two isotopes were then used to calculate the quadrupole coupling values. The average of the four ratios in Table II gives

$$Q(I^{129})/Q(I^{127}) = 0.701213 \pm 0.000015.$$

The original microwave determination[1] of this ratio gave 0.7353. More recent and more extensive micro-

TABLE I. Observed frequencies and assignments for iodine in SnI_4.

Lattice type	Assignment Isotope	Transition ($\lvert m \rvert \rightarrow \lvert m+1 \rvert$)	Frequency, Mc/sec 77°K	20°K
A	I^{129}	$3/2 \rightarrow 5/2$	138.6783	139.2052
A	I^{129}	$5/2 \rightarrow 7/2$	208.0254	208.8157
A	I^{127}	$1/2 \rightarrow 3/2$	207.6855	208.4702
B	I^{129}	$3/2 \rightarrow 5/2$	139.6604	140.2356
B	I^{129}	$5/2 \rightarrow 7/2$	209.4924	210.3556
B	I^{127}	$1/2 \rightarrow 3/2$	209.1324	209.9923

* This work was performed for the U. S. Atomic Energy Commission.

[1] Livingston, Gilliam, and Gordy, Phys. Rev. 76, 149 (1949).

TABLE II. Summary of calculations and results for iodine resonances in SnI_4.

T°K	Lattice type	Freq. ratio, I^{129} $(5/2 \rightarrow 7/2)/$ $(3/2 \rightarrow 5/2)$	$\lvert \eta \rvert$	$e(\partial E_z/\partial z)$ $\times Q^{129}$	$e(\partial E_z/\partial z)$ $\times Q^{127}$	Q^{129}/Q^{127}
77	A	1.5000573	0.00905	970.793	1384.446	0.701214
77	B	1.5000013	0	977.627	1394.216	0.701202
20	A	1.5000568	0.00900	974.481	1389.678	0.701228
20	B	1.500016	0	981.654	1399.949	0.701207

[2] R. Bersohn, J. Chem. Phys. 20, 1505 (1952).

wave measurements[3] by the same authors have given
a ratio in much closer agreement. The crystal structure
of SnI_4 is known,[4] and Dehmelt[5] has made and dis-
cussed higher temperature measurements of the I^{127}
resonance. The lattice is cubic with two nonequivalent
iodine lattice positions. One-quarter of the iodine atoms
lie on C_3 axes of the unit cube and this symmetry re-
quires $\eta=0$ for these atoms. The crystal symmetry does
not require $\eta=0$ for the remaining three quarters of the

iodine atoms. The type B lines for which $\eta=0$ are
appropriately weaker than the corresponding type A
lines in agreement with the crystal structure. Dehmelt's
values for η, determined for I^{127} at room temperature,
are the same as the lower temperature values for I^{129}
given above. His quadrupole coupling value for I^{127} is
appropriately lower than the above values because of
the temperature difference.

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and George Parker of the Chemistry Division, this
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from fission material.

[3] R. Livingston et al. (unpublished results).
[4] R. W. G. Wyckoff, *Crystal Structures* (Interscience Publishers, New York, 1951).
[5] H. G. Dehmelt, Z. Physik **130**, 356 (1951).

Comparison of the Values of the Disintegration Constant of Be⁷ in Be, BeO, and BeF₂*

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The difference in the decay constants of Be⁷ in Be, BeO, and BeF₂, have been measured using the dif-
ferential ionization chamber technique. The results are $\lambda(Be)-\lambda(BeF_2)=(7.41\pm0.47)\times10^{-4}\lambda$, $\lambda(BeO)$
$-\lambda(BeF_2)=(6.09\pm0.55)\times10^{-4}\lambda$, $\lambda(Be)-\lambda(BeO)=(1.31\pm0.51)\times10^{-4}\lambda$. These values are smaller than the
results previously obtained by Leininger, Segrè, and Wiegand for the same compounds, but support their
earlier work.

THE possibility of altering the decay rate of Be⁷ by
changing the electron density at the nucleus was
suggested by Segrè[1] and by Daudel.[2] Experiments per-
formed to determine the influence of different states of
chemical combination of beryllium on the decay con-
stant of Be⁷ have given the results listed in Table I.

The present series of measurements was undertaken
in order to compare $\lambda(Be)$, $\lambda(BeO)$, and $\lambda(BeF_2)$ in
the same experiment, using the improved methods now
available for the measurement of small currents and
for the detection of source contaminants. The ioniza-
tion currents were measured by a vibrating reed elec-
trometer[3] used essentially as a null indicator, thus
eliminating the effects of any variations in the gain or
calibration of the instrument. The use of a scintillation
counter,[4,5] not available in the earlier experiments,[6] is
an aid in detecting and identifying radioactive con-
taminants.

λ-values for different beryllium compounds were
compared by the balanced ionization chamber method
introduced in 1911 by Rutherford.[7] The particular
ionization chambers and current measuring equipment
for this experiment were those used by Bainbridge,
Goldhaber, and Wilson[8] in the study of Tc^{99m}.

I. EXPERIMENTAL PROCEDURE

A. Preparation of the Sources

The Be⁷ was obtained from a proton bombardment
of cp metallic lithium with the 8.5-Mev proton beam
from the cyclotron at the University of Pittsburgh. A
radioautograph was taken of the bombarded target and
the surface containing the Be⁷ activity was scraped and
dissolved in dilute hydrochloric acid. The solution was
made 0.3N in hydrochloric acid, and 50 milligrams
each of iron, nickel, cobalt, copper, zinc, and cadmium
were added. The main contaminant, copper, was pre-
cipitated by hydrogen sulfide. The hydrogen sulfide
was removed from the supernatant, and the active Be⁷
was carried with $Fe(OH)_3$ precipitated by the addition
of ammonium hydroxide. The $Fe(OH)_3$ was dissolved
in dilute hydrochloric acid and again precipitated, in
the presence of the hold back carriers, by ammonium

[1] E. Segrè, Phys. Rev. **71**, 274 (1947).
[2] R. Daudel, Rev. sci. **85**, 162 (1947).
[3] Palevsky, Swank, and Grenchik, Rev. Sci. Instr. **18**, 298 (1947).
[4] H. Kallman, Phys. Rev. **75**, 623 (1949).
[5] R. Hofstadter, Phys. Rev. **74**, 100, 628 (1949).
[6] E. Segrè and C. E. Wiegand, Phys. Rev. **81**, 284 (1951); **75**, 39 (1949).

[7] E. Rutherford, Wien. Ber. **120**, 303 (1911).
[8] Bainbridge, Goldhaber, and Wilson, Phys. Rev. **90**, 430 (1953) [hereafter referred to as BGW].