Disintegration of Ce^{143} and Pr^{143}

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(Received May 31, 1951)

PILE-IRRADIATED "Speckpure" Ce was studied, using mainly spectrometer and coincidence techniques. The β-spectrum consisted of several electron peaks superimposed on a complex continuous β-spectrum. No measurable number of positrons could be observed in the spectrometer[1] using a positron baffle. The photospectrum taken in the same spectrometer showed several photolines. Table I gives the energies of the internal conversion

TABLE I. Energies of internal conversion electrons and photons from Ce^{143} and Ce^{141}.

Energy of the peak kev	Nature of the peak	Energy of the photons kev	Parent isotope
15.7 ±0.5 49.2 ±1	*K*-internal conversion *L*-internal conversion	56.8 ±1	Ce^{143}
27.7 ±1 34.8 ±1	$(K-2L)$ Auger line $(K-L-M)$ Auger line	35.4 ±1	
102 ±1.5 137 ±1 55.7 ±1 125 ±2	*K*-internal conversion *L*-internal conversion *K*-photoline *L*-photoline	143 ±2	Ce^{141}
244.7 ±2 278.5 ±1.5 197.2 ±1 263.2 ±3	*K*-internal conversion *L*-internal conversion *K*-photoline *L*-photoline	283 ±4	Ce^{143}
608.6 ±4 559.2 ±4	*K*-internal conversion *K*-photoline	649 ±4	Ce^{143}
617.4 ±5	*K*-photoline	705 ±5	Ce^{143}

and photoelectron peaks observed in the β- and γ-spectra and the corresponding energies of the photons concerned. All the lines attributed to Ce^{143} in Table I are found to decay with the 33-hour half-life within the statistical errors.

Fermi analysis of the β-spectrum recorded within 24 hours after the sample was taken out of the pile, showed as many as five components and an indication of a sixth component. They are 1.37±0.01 Mev (Ce^{143}), 1.09±0.02 Mev (Ce^{143}), 0.86 Mev (Pr^{143}), 0.57 Mev (Ce^{141}), 0.42 Mev (Ce^{141}), and 0.37 Mev? (Ce^{143}).

Fermi analysis of the β-spectrum taken after eighteen days' decay showed that the first two components 1.37 and 1.09 Mev had disappeared and the maximum energy of the strongest β in this spectrum was 0.915±0.015 Mev corresponding to the β_{max} of Pr^{143} reported by Feldman *et al.*[2] The presence of the intense soft β of Ce^{141} makes it almost impossible to resolve the probable 370-kev β of Ce^{143}.

On the basis that all the Fermi plots are linear, it was found that the 1.09-Mev β is 1.4 times more intense than the 1.37-Mev β. An estimate of the intensity of the γ-rays from the photospectrum showed that the 705- and the 649-kev γ-rays are of almost equal intensity, while the 283-kev γ-ray is about 4.5 times more intense. The intensities given in the disintegration scheme are based on these estimates and are very approximate.

Comparison of the intensity of the Auger lines to that of the *K*-conversion lines in the β-spectrum showed that the Auger electrons are ~12 percent of the *K*-lines. This is precisely what is to be expected for this element of high *Z* value, and it is not necessary to assume the presence of the *K*-capture Ce^{137} (36-hour half-life) in our samples. Probably the slow neutron capture cross section for Ce^{136} is very small, or Ce^{136} is less abundant than it is thought to be.

On the basis of the estimates of the multipolarity of the γ-rays from the internal conversion lines, the *ft*-value considerations of the β-transitions and the spin-orbit coupling model[3,4] of the

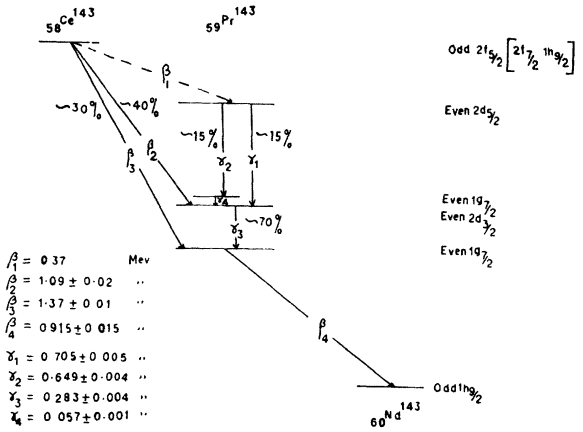

FIG. 1. Proposed decay scheme for Ce^{143} and Pr^{143}.

nucleus, the term schemes for the various levels in the disintegration scheme are suggested in Fig. 1.

Incidentally, from our measurements Ce^{141} appears to emit a single γ-ray of energy 143±2 kev besides the β-rays, and this is in agreement with the observations of Freedman *et al.*[5]

It is a great pleasure to thank Dr. Kai Siegbahn for encouragement and supervision and Professor Manne Siegbahn, the director of this institute, for providing me with all the facilities to work at this institute.

A detailed paper will appear in *Arkiv för Fysik*.

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On the Ratio of the Nuclear Magnetic and Electric Quadrupole Interactions for Atomic Cl^{35} and Cl^{37}

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(Received May 29, 1951)

THE hyperfine structure of the $^2P_{3/2}$ state of the stable chlorine isotopes has been re-examined by the atomic-beam radio-frequency magnetic resonance method. The new measurements disagree with the work of Davis, Feld, Zabel, and Zacharias[1] and resolve the discrepancy that has existed between the ratio of the nuclear magnetic dipole interaction constants, a^{35}/a^{37}, and the ratio of the nuclear magnetic moments μ^{35}/μ^{37} as measured directly in nuclear induction experiments.[2,3] The new results for the ratio of the quadrupole interaction constants, b^{35}/b^{37}, agree with the recent measurements, by Livingston, of the ratio of the chlorine quadrupole interaction constants in solid crystals.[4]

Figure 1 of reference 1 shows the energy levels of an atom with $I=J=\frac{3}{2}$ in an external magnetic field. Deviations from the interval rule may be introduced by the interaction of the nuclear electric quadrupole moment with the gradient of the electric field due to the electrons, by a nuclear magnetic octupole interaction, and by perturbations between adjacent fine structure levels with the same value of the total angular momentum *F*.[5] Theoretically, the latter two are much smaller, but our data indicate that one or both may be present; however, this does not affect the values of *a* and *b* given below. A precision experiment is under way to determine the magnitude of such effects. An experiment is also in progress to measure the ratio a^{35}/a^{37} in the metastable $J=\frac{1}{2}$ state.[6]

The experimental procedure was generally similar to that of D. F. Z. Z.,[1] and only a few details will be given here. Beams con-

TABLE I. Frequencies of various transitions observed in a weak magnetic field.

	Cl^{35}			Cl^{37}		
Transitions used	$(1,0\leftrightarrow 0,0)$	$(2,0\leftrightarrow 1,0)$ $(2,1\leftrightarrow 1,1)$	$(3-1\leftrightarrow 2-1)$	$(1,0\leftrightarrow 0,0)$	$(2,0\leftrightarrow 1,0)$ $(2,1\leftrightarrow 1,1)$	$(3-1\leftrightarrow 2-1)$
Observed frequency (Mc/sec) corrected to $x=0$	150.145	355.244	670.018	127.404	298.116	555.294
Theoretical splitting*	$a-b+100.8c$	$2a-b-50.4c$	$3a+b+14.4c$	$a-b+100.8c$	$2a-b-50.4c$	$3a+b+14.4c$

* The constants a, b, and c are defined in reference 1.

taining as much as 95 percent chlorine atoms were produced by maintaining an arc discharge in a fuzed-quartz tube mounted in a microwave cavity, which was matched to a 50-watt, 10-cm magnetron power supply. Considerably narrower resonances were obtained as a result of improvements in the homogeneous and rf transition fields. All resonances observed were at least 20 times the background unsteadiness in the case of Cl^{37} and as much as 200 times the background unsteadiness in some transitions in the case of Cl^{35}.

In these experiments the spacing between different F levels was observed at magnetic fields of less than 0.5 gauss. The separation of the field independent pairs

$$\begin{pmatrix} 2,0\leftrightarrow 1,0 \\ 2,1\leftrightarrow 1,1 \end{pmatrix}$$

from the field dependent pairs

$$\begin{pmatrix} 2,2\leftrightarrow 1,1 \\ 2,1\leftrightarrow 1,0 \end{pmatrix}$$

was used in second-order perturbation calculations to correct the zero-field hyperfine structure intervals. A typical observed resonance curve is shown in Fig. 1, which corresponds to Fig. 5 of reference 1. The widths of the field-independent transitions are those expected from the uncertainty principle.

The results of these measurements are given in Table I. From them the following values of a and b may be calculated:

$$a^{35}=205.050\pm 0.005 \text{ Mc/sec}, \quad b^{35}=54.873\pm 0.005 \text{ Mc/sec},$$
$$a^{37}=170.681\pm 0.010 \text{ Mc/sec}, \quad b^{37}=43.255\pm 0.010 \text{ Mc/sec}.$$

These data are consistent with a nuclear magnetic octupole of less than 400 cycles for each isotope.

Recent measurements on nuclear magnetic moment ratios are given in Table II. The agreement is seen to be complete within the present experimental errors. Table III lists the results of work on the nuclear electric quadrupole ratios from recent literature. The most accurate data, those of Livingston, agree with our own to within the experimental error. Some microwave absorption measurements,[7] however, are still in disagreement with our results and those of Livingston, for reasons that are not fully understood at present.

TABLE II. Data on the nuclear magnetic constants of Cl^{35} and Cl^{37}.

Method	g^{35}/g^{37}
Nuclear induction[a] using HCl	1.2014 ±0.0001
Nuclear induction[b] using LiCl	1.2013 ±0.0001
Atomic beam magnetic resonance (this paper)	1.20136 ±0.00005

[a] See reference 2. [b] See reference 3.

TABLE III. Recent data on the nuclear electric quadrupole constants for Cl^{35} and Cl^{37}.

Method	$eqQ(Cl^{35})/eqQ(Cl^{37})$
Microwave spectra[a] CH_3Cl	1.2691 ±0.0003
ClCN	1.2682 ±0.0006
GeH_3Cl	1.2670 ±0.0005
Direct quadrupole transitions in solid chlorine compounds[b] (the average of eight measurements on five different solids)	1.26878 ±0.00015
Atomic beam magnetic resonance (this paper)	1.2686 ±0.0004

[a] See reference 7. [b] See reference 4.

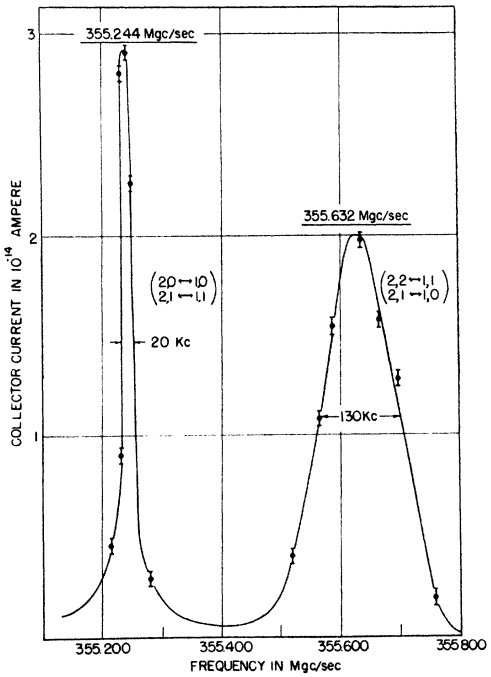

FIG. 1. Observed resonance curves, at a magnetic field of <0.5 gauss, for a field-independent and a field-dependent resonance between the $F=2$ and $F=1$ hyperfine structure levels.

Using Eq. (26) and the relativistic corrections of reference 1, we obtain

$$Q=-(8/3)(\mu_0^2/e^2)(m/M_0)(\mu/I)(\mathfrak{F}/\mathfrak{R})(b/a),$$

and the most recent measurements[2] of μ^{35} and μ^{37}, we obtain

$$Q^{35}=(-0.07894\pm 0.00002)\times 10^{-24} \text{ cm}^2,$$

$$Q^{37}=(-0.06213\pm 0.00002)\times 10^{-24} \text{ cm}^2.$$

We wish to thank Professors B. T. Feld and J. R. Zacharias for their encouragement and assistance.

* This work has been supported in part by the Signal Corps, Air Materiel Command, and ONR.

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