wire detector was analyzed with a mass spectrometer having an enrichment factor of 2000 per mass number at the mass 134 position.

Experimental procedure.—The fields of the two inhomogeneous deflecting magnets were varied until a value of $x=(g_J-g_I)\mu_0H/h\Delta\nu$ (Fig. 1) was obtained in both of them, such that $\mu_{\text{eff}}=0$ for a given magnetic substate m_F, and the beam proceeded undeflected through the apparatus, giving a maximum in detected beam at the mass 134 position.[1] The nuclear spin can then be determined by comparing those transitions for which $\Delta F=0$, $\Delta m_F=\pm 1$ in Cs^{134} with those in Cs^{133} in a weak homogeneous magnetic field, corresponding to the Zeeman effect of the hfs interaction. The frequencies at which these transitions occur are given by the relation

$$\nu^{134}=[(I^{133}+\tfrac{1}{2})/(I^{134}+\tfrac{1}{2})]\nu^{133},$$

and are rendered observable as a decrease in the intensity of the detected beam (zero moment "flop out"). Various integral values of I^{134} were assumed, and only for ν^{134} corresponding to $I=4$ was a resonance observed. This relation was satisfied at various values of the homogeneous field and only at the mass 134 setting of the spectrometer.

The spin was also determined by noting that as the magnitude of the deflecting fields is increased, the ratio of the fields for the last two zero moments is

$$H'/H''\equiv x'/x''=7/5,$$

which is seen to be in agreement with the theoretical ratio from the position of the zero moments for $I=4$ given in Fig. 1.

TABLE I. Observed transition frequencies in Cs^{133} and Cs^{134} and calculated hfs separation $\Delta\nu$.

ν_1^{133} Mc/sec	ν_2^{133} Mc/sec	ν_1^{134} Mc/sec	ν_2^{134} Mc/sec	$\Delta\nu^{134}$ Mc/sec ($\mu+$)	$\Delta\nu^{134}$ Mc/sec ($\mu-$)	Error in $\Delta\nu$ Mc/sec ±
30.822		27.312	27.190	10,571	12,629	220
47.538		42.096	41.751	10,378	11,572	200
47,538		42.096	41.739	10,405	11,483	200
167.910		147.270	142.846	10,487	10,794	20
167.916		147.276	142.858	10,485	10,759	20
	200.158	184.124	177.149	10,465	10,680	14
	200.202	184.155	177.184	10,470	10,685	14
	200.209	184.213	177.206	10,451	10,662	14
	200.216	184.198	177.197	10,460	10,672	14
	200.218	184.209	177.214	10,455	10,693	14

Weighted average: $\Delta\nu^{134}=10{,}465\pm 12$ Mc/sec
$\mu^{134}=+2.96\pm 0.01$ nm[a]

[a] The accuracy assigned allows for the diamagnetic correction and the hfs anomaly.

The magnetic hfs separation $\Delta\nu$ can be determined approximately in our apparatus by observing the magnitudes of the deflecting fields at which the zero moments occur. A more accurate value of $\Delta\nu$, and the sign of the nuclear moment, were obtained from observations of the departure from the linear Zeeman effect of the lines $\nu_1^{134}(9/2, -7/2\leftrightarrow 9/2, -9/2)$ and $\nu_2^{134}(9/2, -7/2\leftrightarrow 9/2, -5/2)$ and comparing these frequencies with the lines $\nu_1^{133}(4, -3\leftrightarrow 4, -4)$ and $\nu_2^{133}(4, -2\leftrightarrow 4, -3)$ in successively higher magnetic fields.

Results and interpretation.—A summary of the experimental measurements is given in Table I. The values of $\Delta\nu^{134}$ were calculated from the Breit-Rabi formula using the recently determined values[2,3] of $g_J(\text{Cs}^{133})$ and of $\Delta\nu^{133}=9192.6323\pm 0.0001$ Mc, assuming both a positive and a negative sign for the nuclear moment $(g_I=-\mu_IM_e/IM_p)$. Agreement is seen to be consistent only if μ_I^{134} is assumed positive. The magnitude of the nuclear moment was calculated from the Fermi-Segrè relation[4] assuming the nuclear moment to be a point dipole. (An experiment is now in progress to measure the nuclear moment directly in order to observe a possible hfs anomaly in the cesium isotopes.)[5]

Considerable interest exists in the spin and magnetic moment of Cs^{134} from the viewpoint of β-decay theory and nuclear shell structure.[6] A spin of 4 and even parity is consistent with the allowed shape of the β-spectrum and the fact that no direct transition to the ground state of Ba^{134} (even-even, $I=0$) exists, implying a large spin change. The spin, and the magnitude and sign of the moment are in excellent agreement with the predictions of nuclear shell structure for a $g_{7/2}-d_{3/2}$ proton-neutron configuration assuming strong spin-orbit coupling for the two independent particles.

Similar results have also been obtained at the Cavendish Laboratory, Cambridge, by Smith and Bellamy.[7]

We wish to thank Professor J. R. Zacharias for his interest and advice. We appreciate the generous aid of Dr. Marvin Fox of the Brookhaven National Laboratory in the procurement of the radioactive sample.

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[1] For a detailed description of the method applied to Cs^{133} see V. W. Cohen, Phys. Rev. **46**, 713 (1934).

[2] P. Kusch and H. Taub, Phys. Rev. **75**, 1477 (1949).

[3] We wish to thank Dr. J. E. Sherwood for sending us the value of $\Delta\nu$ [Phys. Rev. **86**, 618 (1952)].

[4] $(\Delta\nu_1/\Delta\nu_2)=[(2I_1+1)g_1/(2I_2+1)g_2]$ for two isotopes.

[5] A. Bohr and V. F. Weisskopf, Phys. Rev. **77**, 94 (1950).

[6] L. W. Nordheim, Revs. Modern Phys. **23**, 322 (1951).

[7] Private communication from Dr. K. Smith to Professor B. T. Feld. We wish to thank Dr. K. Smith and Dr. E. H. Bellamy for making their results available before publication.

Line Breadth of OCS as a Function of Rotational Transition and Temperature*

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FROM microwave measurements, line breadths of $\text{O}^{16}\text{C}^{12}\text{S}^{32}$ have been determined for the rotational transitions $J=1\rightarrow 2$, $3\rightarrow 4$, $5\rightarrow 6$, and $7\rightarrow 8$ in the ground-vibrational state. In this range, the line breadth increases with the quantum number J. Also, contrary to simple kinetic theory considerations which for fixed N give $\Delta\nu\sim T^{\frac{1}{2}}$, it was found that $\Delta\nu$ was approximately proportional to $T^{-\frac{1}{2}}$. Here $\Delta\nu$ is the line breadth parameter, T the absolute temperature, and N the total number of molecules in the absorbing path.

Table I gives the measured values of $\delta\nu$ for the various conditions of temperature, pressure, and rotational transition. The quantity, $\delta\nu$ is the frequency difference between the inflection points of the absorption line and is related to the line width at half-intensity points, $2\Delta\nu$, by the relation $2\Delta\nu=\sqrt{3}\delta\nu$.[1] Figure 1 shows a plot of $\delta\nu$ as a function of rotational transition for several different pressures and at both dry ice and room temperatures (27°C). At room temperature, it is seen that $\delta\nu$ can be represented quite closely as a linearly increasing function of J. At dry ice temperature $\delta\nu$ still increases with J but seems to depart from linearity at the higher transitions. These results are in poor agreement with Mizushima's[2] theory, which predicts that $\delta\nu$ should be a decreasing function of the rotational transition. However, they do agree with the experimental results reported for the line breadth of ICl at two different transitions.[3,4] Figure 1 also clearly shows the increase in $\delta\nu$ for the decrease in temperature. At present, measurements have been made only at these two temperatures, and, although $\delta\nu\sim T^{-\frac{1}{2}}$ approximates our

TABLE I. Measured values[a] for $\delta\nu$ in Mc/sec for various values of pressure, temperature, and rotational transition.

Transition	Gas pressure at 27°C 0.100 mm Hg 27°	Gas pressure at 27°C 0.100 mm Hg dry ice	Gas pressure at 27°C 0.110 mm Hg 27°	Gas pressure at 27°C 0.110 mm Hg dry ice	Gas pressure at 27°C 0.130 mm Hg 27°C
$J=1\rightarrow 2$	0.72	0.88	0.74	0.91	0.93
$J=3\rightarrow 4$	0.84	1.01	0.90	1.11	1.08
$J=5\rightarrow 6$	0.95	1.21	...	...	...
$J=7\rightarrow 8$	1.16	1.49	1.25	1.62	1.46

[a] The accuracy of these measurements is about ±5 percent.

results fairly well, more data are needed to determine the actual temperature dependence.

A two-meter, brass, K-band cell with no internal dielectrics except the mica windows was used to contain the absorbing gas. After the OCS was introduced into the cell and allowed to come to equilibrium, all the transitions were measured without any additional adjustment in pressure. The pressure was checked at intervals with both a thermocouple and a McLeod gauge and did not vary more than 1 percent during the time of measurement. The measurements at dry ice temperature were made keeping this same quantity of gas in the cell.

The microwave energy was supplied by a 2K33 reflex klystron operating at 24,326 Mc, the frequency of the $J=1\rightarrow2$ transition. The higher transitions were obtained by generating harmonics of this frequency in a crystal multiplier and filtering out the lower frequencies. Thus, transitions were obtained at 48,652 Mc, 72,978 Mc, and 97,304 Mc, corresponding to the $J=3\rightarrow4$, $5\rightarrow6$, and $7\rightarrow8$ transitions, respectively.[5] This klystron was double modulated with a 20-caps sawtooth voltage and a very small 100-kc sine wave voltage. The energy was detected after passing through the cell by a silicon crystal built into the wave guide, and the 100-kc output was fed to a receiver tuned to this frequency and thence to an oscilloscope. The displayed pattern very closely approximated the derivative of the absorption line.[6] To provide markers for measuring the peaks of this derivative curve, the output of another 2K33 klystron, operating cw, was mixed with a variable signal of the order of 0.5 Mc and with energy from the swept klystron. The combined output was detected and fed to a receiver tuned to about 25 Mc, thus giving three marker pips on the oscilloscope when the two klystrons were operating at a frequency separation of about 25 Mc. The frequency spacing of these markers was determined by the low frequency oscillator and could be varied to superimpose either two of them on the line derivative peaks. The markers were of the order of 20 kc wide.

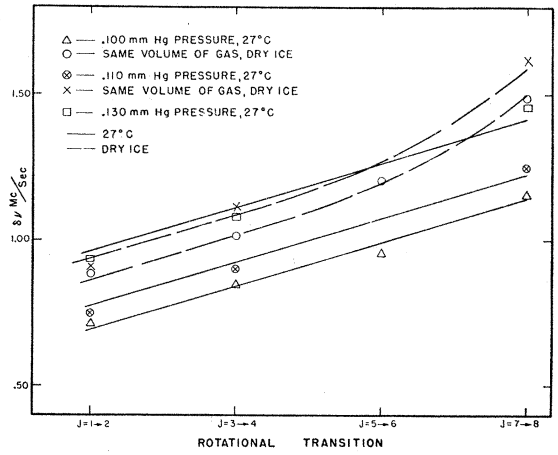

FIG. 1. Plot of $\delta\nu$ as a function of rotational transition.

Great care was taken to eliminate broadening due to power saturation and to minimize reflection amplitudes. Since the derivative shape was considerably distorted when it appeared on the side of a reflection, the symmetry of the peaks was taken as a criterion for minimum reflection effects. Measurements at the different temperatures and for the several transitions were made in various orders to avoid systematic errors. The purity of the sample was checked by searching for the absorption lines of NH_3 and other gases that absorb in the same frequency range. None were found.

Our value of the line breadth parameter for the $J=1\rightarrow2$ transition at room temperature is 6.1±0.35 Mc/mm which checks quite well the width reported by Townes, Holden, and Merritt[7] for this transition.

Further experiments are in progress to extend the measurements both to a greater variation in temperature and to more transitions.

We would like to express our appreciation to Dr. W. V. Smith for suggesting the need for this experiment.

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* This research was supported by the Naval Bureau of Ordnance.

[1] Our detector was operating as a square law device.

[2] Masataka Mizushima, Phys. Rev. **83**, 94 (1951).

[3] Townes, Wright, and Merritt, Phys. Rev. **73**, 1334 (1948).

[4] R. T. Weidner, Phys. Rev. **72**, 1268 (1947).

[5] For precise frequencies of these transitions, see Dakin, Good, and Coles, Phys. Rev. **71**, 640 (1947); Hillger, Strandberg, Wentink, and Kyhl, Phys. Rev. **72**, 157 (1947); Johnson, Trambarulo, and Gordy, Phys. Rev. **84**, 1178 (1951).

[6] R. R. Howard and W. V. Smith, Phys. Rev. **79**, 128 (1950).

[7] Townes, Holden, and Merritt, Phys. Rev. **74**, 1113 (1948).

An Absolute Determination of the X-Line from ThC''

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THE X-line of ThC'' (Ellis' notation), which is a high energy internal conversion line from the K-shell, has been used by many workers as a calibrating line in β-spectroscopy. The binding energy of the deuteron, for example, has been measured in terms of the energy of this line.[1] It is therefore of some importance to get a reliable $H\rho$-value. Brown[2] has recently measured this value by a method similar to the present one, but his value, 9988.4±2 gauss cm, did not agree with the relative measurements made by Hedgran and Lind.[3]

The present investigation was carried out in order to make an independent check of Brown's value. The experimental arrangement was about the same as that used in the measurements of the F, I, and L-lines of Th(B+C+C'')[4,5] and consists of a small semicircular β-spectrograph and two G.M.-tubes in coincidence. The main difference is that the two tubes are placed at right angles to each other (Fig. 1).

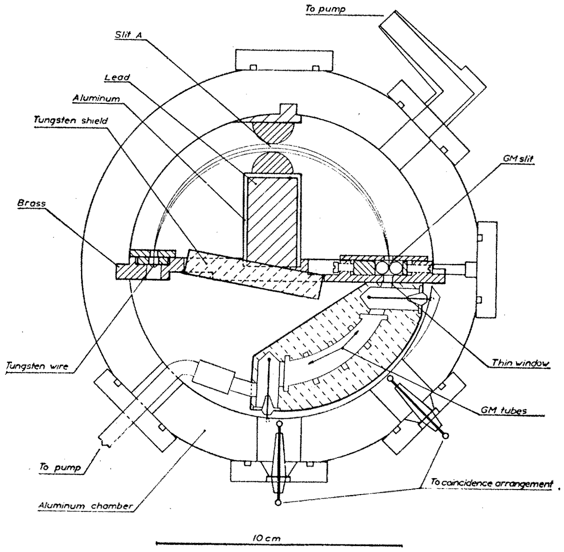

FIG. 1. Construction of the β-spectrograph.

The X-line is rather weak, but with this arrangement it was possible to register the line with a half-width of less than 0.1 percent and to get a peak of about 6 times the background, in spite of the small dimensions and the hard γ-rays from the sample. The line obtained was in good agreement with the calculated line shape. The source consists of an activated tungsten wire (diameter 12μ).