δ^2. The potential deduced from the experimental cross section is then $\mathfrak{U}_\delta$, which should be divided by δ to obtain $\mathfrak{U}_c$.

It appears that the $1/A$ corrections occur in a rather simple manner and indeed tend to cancel each other somewhat.

Equations (A-7) seem to be more difficult to tackle than Eqs. (50). That is, Eqs. (A-7) includes *elastic* scatterings in excited nuclear states. These are already taken into account in Eqs. (50) by the appearance in that equation of $1/e$ rather than $1/a$.

Another (related) difference between Eqs. (50) and (A-7) is that the scattering operators t_α are different in these two equations. The incident energy in the t_α of Eqs. (50) is corrected to be the energy of the particle *in the medium*. [This point was discussed in Appendix (A) of reference 1.] As was also shown in I, the fact that this energy has a small imaginary part does not lead to significant corrections—at least, where the imaginary part is no larger than it seems to be for mesons. It thus appears that certain complicated properties of Eqs. (A-7) appear in a more natural and simple manner in Eqs. (50).

As a final remark, we note that our rather free use of operators such as $(a-\mathfrak{V})^{-1}$ is justified if there exists the Møller wave matrix,

$$\omega=1+a^{-1}\mathfrak{V}\omega,$$

since $(a-\mathfrak{V})^{-1}$ can be defined to be

$$\omega a^{-1}.$$

Therefore, all the results of this paper and of reference 1 depend upon the existence of such quantities ω. In particular, the entire derivation may be carried out in terms of the solution to integral equations and without the use of the more formal algebraic treatment which was actually employed.

PHYSICAL REVIEW VOLUME 92, NUMBER 2 OCTOBER 15, 1953

The Nuclear Moments of Technetium-99

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(Received May 15, 1953)

The hyperfine structure in the optical spectrum of technetium has been investigated in the region 3600–7000A with a Fabry-Perot interferometer crossed with a quartz prism spectrograph. The light source was a liquid-nitrogen-cooled hollow cathode discharge tube. The nuclear-spin, magnetic moments previously reported by one of us are confirmed ($I=9/2\hbar$ and $\mu=5.5\pm0.3$ nm) and are in agreement with a more recent nuclear induction measurement. The quadrupole moment of Tc^{99} is found to be: $Q=(+0.34\pm0.17)\times10^{-24}$ cm^2.

I. INTRODUCTION

ELEMENT 43 was first prepared in 1937 in the Berkeley cyclotron by neutron bombardment of molybdenum, and was named technetium (Tc) by Perrier and Segrè.[1,2] In 1948, milligram amounts of Tc^{99} were separated from uranium fission products by Parker, Reed, and Ruch.[3] A 3-mg sample of Tc^{99} was received by the spectroscopy laboratory of the National Bureau of Standards in January, 1949, for a preliminary investigation of the arc and spark spectra of the element.[4,5] In July, 1950, an additional amount of 3 mg was received from the Atomic Energy Commission for further work on the spectra of Tc. Wavelength measurements on 2121 lines in Tc I and Tc II were published by Meggers and Scribner,[6] and a preliminary analysis identifying 20 terms of Tc I and 4 terms of Tc II was published by Meggers.[7]

Of the second sample received, 2 mg were saved for an investigation of the hyperfine structure (hfs) of Tc. The nuclear spin (9/2) was determined by Kessler and Meggers[8] and a preliminary value (5.2 ± 0.5 nm) of the magnetic moment of the Tc nucleus was reported.[9] More recently a 7-mg sample of Tc^{99} has been received from the Oak Ridge National Laboratory. Four mg have been used to improve the descriptions of the arc and spark spectra, and the remainder was devoted to the investigation of the hfs of Tc reported below.

A nuclear induction experiment on 156 mg of Tc^{99} by Walchli, Livingston, and Martin[10] yielded for the magnetic moment a value of 5.6805 ± 0.0004 nm, consistent with our preliminary value.

[1] C. Perrier and E. Segrè, J. Chem. Phys. **5**, 712 (1937); **7**, 1 (1939).
[2] C. Perrier and E. Segrè, Nature **159**, 24 (1947).
[3] Parker, Reed, and Ruch, Clinton National Laboratory Report CNL-1, 1949 (unpublished).
[4] W. F. Meggers and B. F. Scribner, Y-476, Oak Ridge Spectroscopy Symposium, Abstracts of Papers, March 24 to 25, 1949 (unpublished).
[5] W. F. Meggers and B. F. Scribner, J. Opt. Soc. Am. **39**, 1059 (1949).
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[9] K. G. Kessler and W. F. Meggers, Phys. Rev. **82**, 341 (1951).
[10] Walchli, Livingston, and Martin, Phys. Rev. **85**, 479 (1952).

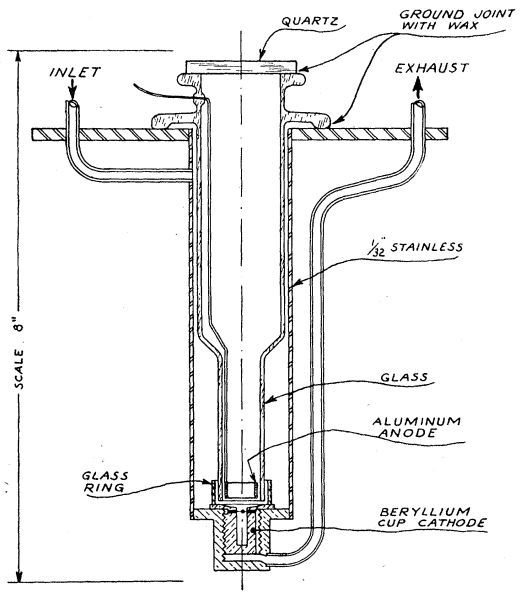

FIG. 1. Beryllium cup, liquid-nitrogen-cooled hollow cathode discharge tube. The technetium compound is deposited on the inner wall of the cathode cup. A stream of helium or argon gas passes down the tube, through the cup, and out through the bottom of the tube. The lower 4 inches of the tube is immersed in liquid nitrogen during operation.

II. EXPERIMENTAL PROCEDURE

(a) The Light Source

The source used was a liquid-nitrogen-cooled hollow cathode tube, shown in Fig. 1. The body of the tube is constructed of stainless steel to minimize the longitudinal heat flow. The lower end of the tube, which consists of a threaded brass plug, is immersed in liquid nitrogen to reduce the Doppler broadening of the spectral lines. The slow flow of heat down the tube walls permits the upper end to remain moderately warm, thus avoiding brittleness and cracking of the wax joints, and condensation on the window.

The beryllium-cup cathode is a modification of a design suggested by Schüler and Gollnow.[11] Three radial holes are drilled near the upper end of the cup, and these are connected to a longitudinal slot in the outside surface of the threaded cup. In operation, the carrier gas flows into the upper part of the cup, out through the radial holes, down the channel and out through the bottom of the tube. The flow pattern is such as to inhibit the loss of material out of the cup, while supplying clean gas for the discharge. The gas cleaning and circulating system consists of two liquid nitrogen traps, one on either side of the discharge tube, a mercury diffusion pump to circulate the gas, and a heated quartz tube filled with copper oxide to remove hydrogen gas. Carrier gases used were argon and helium at pressures of approximately 1-mm Hg. In the case of the helium carrier, one of the liquid nitrogen traps was filled with activated charcoal.

The cathode and anode were connected in series with a ballast resistor to a 1000-volt dc power supply. In normal operation, the potential fall across the discharge tube was 100 to 125 volts at a current of 85 to 120 ma.

The Tc^{99} was received in the form of the soluble ammonium pertechnate NH_4TcO_4. The salt was dissolved in pure water and slowly evaporated to dryness inside the beryllium cup. By careful manipulation, a thin layer of the salt was formed on the inside surface of the cathode.

Because the mechanism of the hollow cathode discharge depends on the excitation of ions sputtered into the discharge column by the gas ions striking the cathode surface, it is advantageous to use for the cathode a metal that has a low rate of sputtering. Beryllium has an extremely low rate,[12] and therefore this metal was used in the construction of the cathode cup.

(b) Dispersive Apparatus

The light from the hollow cathode discharge was collimated by a simple quartz lens mounted above the tube window. The collimated beam was reflected in a horizontal direction by a front-surface mirror and passed through a Fabry-Perôt interferometer. The interference pattern was then focused on the slit of a large Gaertner quartz spectrograph by a quartz-fluorite achromat of 50-cm focal length. Quartz interferometer plates coated with either aluminum or silver were used with 3.75 and 5 mm separators of invar. The plate curvature in the spectrograph was modified to yield optimum focus for the interferometer pattern. Eastman 103aF plates were used, and exposure times varied from 15 to 45 minutes.

III. RESULTS

(a) Data

Interference spectrograms covering the wavelength region 3600–7000A yielded 72 lines of Tc I. Of these, 36 were sufficiently resolved so that the hfs splitting factors could be calculated for at least one of the energy levels involved. The hfs patterns on these plates were measured with a comparator, by using the standard eyepiece and crosshairs on all lines. Those lines used in the calculation of the quadrupole moment were also measured on the same comparator, with a photo-electric scanning device.[13]

(b) Nuclear Spin

As many as 9 resolved hfs components have been observed in lines of Tc I, and all interval ratios observed are in agreement with a value of $I=9\hbar/2$, as previously reported.[8]

[11] H. Schüler and H. Gollnow, Z. Physik **93**, 611 (1935).

[12] E. O. Hulburt, Rev. Sci. Instr. **5**, 85 (1934).

[13] F. S. Tomkins and M. Fred, J. Opt. Soc. Am. **41**, 641 (1951).

(c) Nuclear Magnetic Moment

Preliminary investigation[9] of the hfs of Tc^{99} yielded a value of $+5.2\pm0.5$ nuclear magnetons for the magnetic moment of the Tc^{99} nucleus. Walchli, Livingston, and Martin[10] subsequently reported a value of $\mu=+5.6805\pm0.0004$ nm which they measured by nuclear-induction methods. The precision attained by nuclear resonance techniques cannot be matched by optical methods. However, comparison of the optical data with the resonance value is helpful in studying the the validity of approximations involved in the optical experiment. Insufficient information on the energy levels in Tc I and Tc II contributes to considerable uncertainty in the ionization potentials, and more particularly in the quantum defect corrections. In several terms, deviations from the nuclear induction value may be attributed to a mixture of term parentage.

In the case of the ^6D term, the term parentage is pure and the value of the energy to remove the electron is reasonably well known. The good agreement with the nuclear induction value (within 2.5 percent) supports the statement by Breit[14] that in some cases there is experimental evidence that the accuracy of the Goudsmit-Fermi-Segrè formula is good, despite the lack of sound theoretical foundation.

The interval factors for the five principal terms are given in Table I. These factors were derived for the $a\,^6D$, $a\,^4D$, and $e\,^6S$ terms by the method of graphical analysis suggested by Fisher and Goudsmit.[15] Nearly all of the estimated errors in the interval factors for these configurations are attributable to the uncertainty in determining the proper interval factor ratio for the two terms involved in the transition. The $z\,^8P^\circ$ and $z\,^6P^\circ$ terms are analyzed in transitions to the ground state $a\,^6S$, which has nearly zero hfs splitting. The interval factors for these terms are derived by the formula[5] given in the following section on the quadrupole moment.

The electron coupling constants for the individual electrons were calculated from the interval factors with the formulas of Table II. These formulas were derived by one of us in the accompanying paper.[16] The values of the coupling constants, a_l, calculated from the above formula [formula (3) in RET] by the method of least squares, are given in Table III.

The magnetic moments were calculated by use of the Goudsmit formula:[17]

$$\mu=0.431IZ_0a_s\times10^{10}/Z_iW^{\frac{3}{2}}\kappa, \qquad (1)$$

where $I=9/2$; Z_0 is the effective charge outside the nucleus and is taken to be 1 for the neutral and 2 for the singly ionized atom; a_s is the coupling constant for s electrons; Z_i, the effective charge near the nucleus, is taken as 43 for the s electron; W is the energy in units[18] of K necessary to remove the electron in question and $\kappa=1.22$ is the relativity correction. Thus, Eq. (1) reduces to

$$\mu=3.70\times10^8Z_0a_s/W^{\frac{3}{2}}. \qquad (2)$$

Values of μ are listed in Table III for the following five terms:

(1) $(4d^6(a\,^5D)5s)a\,^6D$.

This configuration has pure parentage and should give a reliable value for μ. The principal errors involved are: (a) the uncertainty in the value of the ionization potential (58 297K),[19] (b) the uncertainty introduced in determining the interval factors by graphical analysis,[14] and (c) the omitted Fermi-Segrè correction.[20]

By using a value of 4161.2K for the centroid value of $a\,^5D$ in Tc II[21] and 3277K for $a\,^6D$ in Tc I, the energy to remove the $5s$ electron becomes $W=59\,181$K, yielding $\mu=5.93$ nm. There are insufficient data available in Tc to calculate the Fermi-Segrè quantum defect correction. It is possible, however, to obtain a rough approximation to this correction from the corresponding terms in Mn I. If the magnetic moment is divided by the correction factor $[(1-d\sigma/dn)=1.07]$ from Mn I, the corrected value of the magnetic moment, shown in Table III, becomes $\mu=5.54$ nm. In view of the approximations involved, the agreement with the nuclear induction value of $\mu=5.68$ is good.

(2) $(4d^5 5s(a\,^7S)5p)z\,^8P^\circ$.

The energy necessary to remove the $5s$ electron was calculated for the second spectrum. Removal of the $5p$ electron leaves the configuration $(4d^5(a\,^6S)5s)a\,^7S$, the ground state of Tc II. The energy to remove the $5s$

TABLE I. Interval factors.

Configuration	Term symbol	J	Interval factor (A)	Coupling factor (B) $\times10^6$
$4d^6(a\,^6D)5s$	$a\,^6D$	9/2	$+0.025\pm0.001$	···
		7/2	$+0.030\pm0.001$	···
		5/2	$+0.032\pm0.001$	···
		3/2	$+0.039+0.001$	···
		1/2	$+0.07\pm0.02$	···
$4d^55s(a\,^7S)5p$	$z\,^8P^\circ$	7/2	$+0.0345\pm0.0001$[a]	-3.7 ± 2.2[a]
		5/2	$+0.0351\pm0.0001$[a]	-1.9 ± 2.2[a]
$4d^6(a\,^5D)5s$	$a\,^4D$	7/2	-0.018 ± 0.002	···
		5/2	-0.016 ± 0.002	···
$4d^55s(a\,^7S)5p$	$z\,^6P^\circ$	7/2	$+0.0292\pm0.0004$	0.0 ± 4
		5/2	$+0.0336\pm0.0004$	-6.8 ± 4
		3/2	$+0.0442\pm0.0004$	$+3.0\pm4$
$4d^55s(a\,^7S)6s$	$e\,^6S$	5/2	$+0.048\pm0.001$	···

[a] Errors marked are standard deviation, others are estimated.

[14] G. Breit, "Report of Subcommittee h, Joint Commission for Spectroscopy," J. Opt. Soc. Am. **43**, 427 (1953).
[15] R. A. Fisher and S. Goudsmit, Phys. Rev. **37**, 1057 (1931).
[16] R. E. Trees, following paper [Phys. Rev. **92**, 308 (1953)], hereafter referred to as RET.
[17] S. Goudsmit, Phys. Rev. **43**, 636 (1933).
[18] We have used the notation K (kayser) for cm^{-1}, the unit of wave numbers, in accordance with recommendations of the Joint Commission for Spectroscopy, J. Opt. Soc. Am. **43**, 410 (1953).
[19] M. A. Catalán and F. R. Rico, Anales ffs. y quím. (Madrid) **A48**, 328 (1952).
[20] E. Fermi and E. Segrè, Z. Physik **82**, 729 (1933).
[21] W. F. Meggers (unpublished).

TABLE II. Interval factor formulas.

$a\ ^6D$	$a\ ^4D$
$A(9/2)=0.1111a_s+0.5079a_d$	$A(7/2)=-0.086a_s+0.498a_d$
$A(7/2)=0.1175a_s+0.3574a_d$	$A(5/2)=-0.074a_s+0.719a_d$
$A(5/2)=0.1314a_s+0.2090a_d$	$\zeta(\alpha SL)=-(3/10)\zeta_d$
$A(3/2)=0.1733a_s+0.0076a_d$	$z\ ^6P^\circ$
$\zeta(\alpha SL)=-1/5\zeta_d$	$A(7/2)=0.1361a_s+0.3265a_p$
$z\ ^8P^\circ$	$A(5/2)=0.1687a_s-0.0065a_p$
$A(7/2)=0.1338a_s+0.1814a_p$	$A(3/2)=0.2667a_s-0.3200a_p$
$A(5/2)=0.1837a_s-0.3592a_p$	$B(7/2)=0.0381b_p$
$B(7/2)=-0.0508b_p$	$B(5/2)=-0.0914b_p$
$B(5/2)=+0.0285b_p$	$B(3/2)=0.0533b_p$
$\zeta(\alpha SL)=(1/7)\zeta_p$	$\zeta(\alpha SL)=-(1/7)\zeta_p$
	$e\ ^6S$
	$A(5/2)=0.1905a_{5s}-0.1429a_{6s}$

electron is then the ionization limit of Tc II, or $W=120\,000$K.[19] The calculated value of the magnetic moment ($\mu=4.11$ nm) is low, but perhaps not unreasonably so in view of the uncertainty in the ionization limit and the approximation involved in going to the second spectrum. Inclusion of the Fermi-Segrè correction is this calculation would further lower this value.

(3) $(4d^6(a\ ^5D)5s)a\ ^4D.$

The energy necessary to remove the $5s$ electron is equal to the difference between the $a\ ^4D$ term ($W=11\,030$K) and the $a\ ^5D$ term in Tc II ($W=58\,297+4161$K). The resultant value ($W=51\,428$K) gives $\mu=6.78$ nm. If we take the quantum defect correction factor 1.07 from Mn I, the value of the magnetic moment becomes $\mu=6.34$ nm. Part of the discrepancy here may lie in the approximation involved in the Fermi-Segrè correction. A correction factor of 1.12 would yield complete agreement.

(4) $(4d^5 5s(a\ ^7S)5p)z\ ^6P^\circ.$

The energy to remove the $5s$ electron must again be taken from the second spectrum. As in $z\ ^8P^\circ$, the energy to remove the $5s$ electron is $W=120\,000$K. The corresponding value of μ ($=3.35$ nm) is low, again for reasons pointed out in $z\ ^8P^\circ$. The parentage here is also a mixture of ^7S and ^5S, which would lower the value of the magnetic moment, as observed.

(5) $(4d^5 5s(a\ ^7S)6s)e\ ^6S.$

In order to remove the $5s$ electron we must again go to the second spectrum ($W=120\,000$K). This yields a value of $\mu=4.98$ nm. A principal source of uncertainty here lies in the assumption of the value 8.1 for the ratio a_{5s}/a_{6s}. This approximation to the interval factor ratio for the two s electrons was derived from the Goudsmit formula:

$$\frac{a_{5s}}{a_{6s}}=\frac{(Z_0)_{6s}}{(Z_0)_{5s}}\left(\frac{W_{5s}}{W_{6s}}\right)^{\frac{3}{2}}=8.1. \qquad (3)$$

The quantum defect correction here reduces the value of the magnetic moment to $\mu=4.33$ nm.

The values of a_p and a_d, empirical values of which are shown in Table III, can be calculated from Eq. (10) in RET as a check on the internal consistency of the measurements. Using values of $\lambda=1.03$ and $g=1.26$, we have:

$$a_l=\frac{0.545\times1.26\times10^{-3}\zeta_l}{1.03Z_i}=0.667\times10^{-3}\frac{\zeta_l}{Z_i}. \qquad (4)$$

A discussion of the values of ζ_l as determined from the fine structure is given in the Appendix. For a p electron, $\zeta_p=960$ and $Z_i=41$, then $a_p=0.016$. This is in moderately good agreement with the observed values of $a_p=0.017$ for the $z\ ^6P^\circ$ level and $a_p=0.021$ for the $z\ ^8P^\circ$ level. In the case of a d electron, $\zeta_d=670$ and $Z_i=33$, therefore $a_d=0.013$. This value is considerably larger than the observed values of 0.003 and $\leqslant 0.001$ for the $a\ ^6D$ and $a\ ^4D$ terms respectively. Both these terms are derived from transitions in which the other level involved does not have zero splitting, and the graphical analysis necessary in such cases involves errors of the order of ±0.005.

The average of the corrected values of the magnetic moment from Table III is $\mu=5.40$ nm. The most reliable value is that from the $a\ ^6D$ term, $\mu=5.54$ nm.

(d) Nuclear Electric Quadrupole Moment

Calculations of the quadrupole moment were found to be feasible only with the data derived from transitions in which one of the terms involved has negligible hfs splitting. In all other cases, the uncertainty introduced in fitting the observed pattern to the combined effect of two splitting factors was greater than the quadrupole effect. The transitions from which quadrupole data were derived are from the $z\ ^8P^\circ$ and $z\ ^6P^\circ$ terms to the ground state $a\ ^6S$.

Values of the magnetic splitting factor A and the quadrupole coupling factor B were calculated from the observed intervals with the interaction formula

$$W_F=W_J+\tfrac{1}{2}AK+BK(K+1),\qquad K=F(F+1)-I(I+1)-J(J+1). \qquad (5)$$

Values of A and B are tabulated in Table I, together with the standard deviation of the mean in each case. Six exposures were available for each line, and measurements on each were repeated at least four times.

The relations between the coupling factor B and the parameter b_p, taken from Eq. (12) of RET, are given in Table II. The value of the quadrupole moment Q can be calculated with formula 15 of RET:

$$b_l=\frac{0.253\zeta_l Q\times10^{21}}{\lambda Z_i I(2I-1)},$$

where $\lambda=1.03$, $I=9/2$ and $Z_i=41$ for the p electron. The value $\zeta_p=960$ was used in both $z\,^6P^\circ$ and $z\,^8P^\circ$ for reasons discussed in the Appendix.

The values of b_l and Q calculated from the $z\,^8P^\circ$ and $z\,^6P^\circ$ levels are given in Table III. The final value of Q has been calculated by using as a weighting factor in each case the reciprocal of the standard deviation squared of the individual measurements from Table III. The final value of the nuclear quadrupole moment is $Q=+0.34\times10^{-24}$ cm^2 with a standard deviation of the mean of 0.17×10^{-24} cm^2.

The observed value of Q corresponds to a shift of the order of 1 percent in the energy level spacing, and it is, therefore, very close to the limit of precision attainable in the measurement of these intervals. A significant result could be obtained only by combining the calculated Q values from five different levels, where the hfs of each level was measured some 25 times.

It is also possible that the regular variation in intensity and spacing found in hfs patterns may introduce a small systematic bias into the determination of line centers. Such a systematic error of the same sign and approximate magnitude would affect the $^8P_{7/2}$ and $^6P_{5/2}$ terms in one direction and the $^8P_{5/2}$, $^6P_{7/2}$ and $^6P_{3/2}$ terms in the opposite direction. The fact that the Q values of the latter set of levels are generally smaller than those in the first pair may indicate the presence of such a systematic error. The direction of this bias would be opposite to that required to produce an error in the sign of Q.

Sources of perturbations are discussed from the theoretical viewpoint in RET. None of these errors is likely to affect significantly the Q value obtained in Tc. A similar analysis of the homologous spectrum of Mn I in RET yielded a positive Q value somewhat higher than the positive value obtained from recent microwave experiments.

If one assigns 95 percent confidence limits to the value of the quadrupole moment, one has:

$$Q=(+0.34\pm0.34)\times10^{-24}\text{ cm}^2.$$

A small negative Q is not excluded, however.[22]

Complete details of the hfs patterns will be published in the National Bureau of Standards Journal of Research in conjunction with an extended analysis of both Tc I and Tc II. We wish to express our appreciation to Mr. Joseph Cameron of the National Bureau of Standards Statistical Engineering Laboratory for valuable aid in analyzing the quadrupole moment data.

This work has been carried out in the Spectroscopy Section of the National Bureau of Standards as part of the program initiated by W. F. Meggers to study the spectra of technetium. We are indebted to G. W. Parker of the Oak Ridge National Laboratories for supplying the excellent samples of Tc^{99}.

[22] The plot of Q values given by Townes, Foley, and Low [Phys. Rev. **76**, 1415 (1949)] indicates a small Q for Tc. The empirical rule of Bene, Denis, and Extermann [Phys. Rev. **76**, 1255 (1949)] indicates that the Q of Tc should be greater than the Q in Nb. Since no limits are given on the value $Q\approx0$ in Nb [W. W. Meeks and R. A. Fisher, Phys. Rev. **72**, 451 (1947)] it would not be safe to conclude from this that a positive Q is expected in Tc. It has been pointed out to us that, according to the shell model, the Q of Tc should be negative in contradiction to our observed result.

TABLE III. Dipole and quadrupole moments from the terms of Tc I.

Term	Coupling constant	Magnetic moment (nm) Uncorrected	Magnetic moment (nm) Corrected	J	b_l	$Q\times10^{+24}$ (cm^2)
$a\,^6D$	$a_s=0.231$ $a_d=0.003$	5.93	5.54			
$z\,^8P^\circ$	$a_s=0.0231$ $a_p=0.021$	4.11	···	7/2 5/2	+0.72 −0.67	+0.47±0.28 −0.44±0.51
$a\,^4D$	$a_s=0.214$ $a_d\leq0.001$	6.78	6.34			
$z\,^6P^\circ$	$a_s=0.188$ $a_p=0.018$	3.35	···	7/2 5/2 3/2	0.00 +0.75 +0.57	+0.00±0.69 +0.49±0.29 +0.37±0.49
$e\,^6S$	$a_{5s}=0.277$ $a_{6s}=0.034$	4.98	4.33			
		Mean	5.4		Mean	+0.34±0.17

APPENDIX

Evaluation of the Parameters ζ_p and ζ_d

The parameter $\zeta(\alpha SL)$ is calculated from the observed fine structure. It is equal to the fine structure intervals divided by the higher J value. Formulas for calculating the parameters for the individual electrons, ζ_p and ζ_d, from $\zeta(\alpha SL)$ taken from formula 51, RET, are given in Table II. For $z\,^8P^\circ$, $\zeta_p=960$, which is consistent with the data on four other terms analyzed. In the case of $z\,^6P^\circ$, however, $\zeta_p=380$. This low value is probably the result of a mixture of $4d^55s\,^7S$ and $4d^55s\,^5S$ parentage in this term. Such a mixture would make the calculated value of the magnetic moment too small, as is the case. The value $\zeta_p=960$ was therefore used in calculating the quadrupole moment from the $z\,^6P^\circ$ term. The values of B_J are the same for both $z\,^6P^\circ$ and $y\,^6P^\circ$ terms, so that mixing of parents will not effect the matrix element needed to calculate the quadrupole moment. The value of $\zeta_d=670$ used in calculating a_d in the section on the magnetic moment is the same for both $a\,^6D$ and $a\,^4D$ terms and is in good agreement with the values calculated for five out of eight terms analyzed.