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Magnetic Moment of Os^{189}†

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A NUCLEAR induction signal of Os^{189} with a width of 10 gauss, measured between the minima of the differentiated dispersion mode, has been detected in molten OsO_4. The liquid phase of this particular compound was chosen because the Os^{189} nucleus has a large electric quadrupole moment, $Q=(+2.0\pm0.8)\times10^{-24}$ cm^2,[1] and its is therefore necessary to place the nucleus in a symmetric molecular configuration in order to minimize interactions which broaden the resonance line. It is presumed that in our sample, the osmium nucleus is located at the centroid of a tetrahedron having oxygen atoms at its vertices.

The resonant frequency was compared to that of Cl^{35} in pure $TiCl_4$ with the result

$$\nu(Os^{189})/\nu(Cl^{35})=0.791896\pm0.000093. \qquad (1)$$

With the spin of Os^{189} assumed to be 3/2,[1] and with the known values of the frequency ratios $\nu(Cl^{35})$ in $TiCl_4$/$\nu(Cl^{35})$ in RbCl,[2] $\nu(Cl^{35})$ in RbCl/$\nu(H^2)$,[3] $\nu(H^2)/\nu(H^1)$,[4] the value of the magnetic moment was found to be, with $\mu(H^1)=2.79268$,[5]

$$\mu(Os^{189})=+0.650655\pm0.000081 \text{ nm}. \qquad (2)$$

The positive sign in (2) was verified by comparing the sign of the Os^{189} signal with that of O^{17} in the same compound. Sign comparisons were also made with H^2 and N^{14}. The earlier determination of $\mu(Os^{189})=+0.70\pm0.09$ nm by Murakawa and Suwa[1] is in agreement with the sign and the more precise value of Eq. (2).

In view of the fact that the single-particle shell model[6] predicts that, for the case of a positive magnetic moment, only $p_{1/2}$, $f_{5/2}$, and $h_{9/2}$ states are available between the magic numbers 82 and 126, it seemed to us of interest to check the previous spin determination by an independent method. Accordingly, the heights h and line widths ΔH of Os^{189} and Cl^{37} signals were compared. The reference Cl^{37} signal from a 7.10 molar LiCl solution containing 0.0075 molar $Mn(NO_3)_2$ was used, and care was taken to ascertain that both line shapes represented the nonsaturated slow passage case. If the frequency, the rf field intensity, the Q of the receiver coil, the filling factor, and the sweep field remain unchanged for the measurements of both signals, the application of the phenomenological equations[7] gives

$$I(\mathrm{Os})[I(\mathrm{Os})+1]=I(\mathrm{Cl})[I(\mathrm{Cl})+1] \times\frac{h(\mathrm{Os})}{h(\mathrm{Cl})}\frac{N(\mathrm{Cl})}{N(\mathrm{Os})}\frac{\gamma(\mathrm{Cl})}{\gamma(\mathrm{Os})}\left(\frac{\Delta H(\mathrm{Os})}{\Delta H(\mathrm{Cl})}\right)^2. \qquad (3)$$

With the known value of 3/2 for $I(\mathrm{Cl})$,[8] the measured values of the number of nuclei N in each sample, and our experimental results for the other ratios, we find

$$I(Os^{189})=1.45\pm0.13, \qquad (4)$$

thus verifying the value 3/2.

Signals were not observable in solidified OsO_4 or in powdered Os metal which has a crystal structure of hexagonal symmetry, presumably because of an unfavorable ratio T_2/T_1.

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Experimental Study of the μ^- Meson Mass and the Vacuum Polarization in Mesonic Atoms*

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STUDIES of the x-rays emitted in transitions of mesons between atomic orbits about nuclei have been extended[1] to $3D-2P$ and $4F-3D$ transitions in a variety of elements for both π^- and μ^- mesons. Particular attention has been paid to μ^- mesonic transitions having energies below 90 kev, using thin filters between the anticoincidence counter and the NaI crystal of the scintillation spectrometer.[2] Because of the large and rapid change in absorption cross section at the photoelectric "K edge" energy and the precise knowledge of these energies,[3] it is possible to state whether a particular mesonic x-ray lies above or below the "K edge" of a given filter element and thus place an upper or lower limit on the energy of that transition. Calculated mesonic x-ray energies in this energy range are only slightly affected by readily evaluated nuclear size corrections; other effects,[4] except for the vacuum polarization, are considered negligible. A large number of such transitions have been studied to date. The observed pulse-height spectra contain components of degraded radiation arising from Compton scattering in the meson target and surrounding material and fluorescent radiation from the filter. Thus the upper energy part of the pulse-height distribution is emphasized in the interpretation of the data.

At present, the results of most interest in the determination of the μ^- meson mass and of vacuum polarization effects are the following. For the $2P-1S$ transition in carbon, $Z=77$, 78, 79 filters all behave similarly indicating "K edges" above the mesonic x-ray energy while $Z=74$ has its "K edge" well below the mesonic energy. The $Z=77$ filter indicates that the transition energy is below 76.123 kev. The most significant result was that the phosphorus $3D-2P$ transition energy lies above the $Z=81$ and 82 absorption edges and below the $Z=83$ edge. Corresponding to the $Z=82$ absorption edge we emphasize that the photon energy in this case is greater than 88.065 kev. The $4F-3D$ transition in silicon indicates that the transition energy is above the $Z=47$ and 48 absorption edges and below that for $Z=49$, corresponding to a transition energy greater than 26.713 kev for the $Z=48$ edge.

The lowest-order vacuum polarization effect, as given by the Uehling integral,[5] has been evaluated for these states by two independent approximate methods which agree to within 2 percent. The effect always increases the binding energy. This amounted to 0.40 percent, 0.099 percent, 0.25 percent, 0.103 percent, 0.094 percent, and 0.034 percent for the $1S$ and $2P$ levels in carbon, the $2P$ and $3D$ levels in phosphorus, and the $3D$ and $4F$ levels in silicon, respectively. Table I lists the corresponding upper or lower limits on the μ^- meson mass before and after applying the vacuum polarization correction. The Dirac formula for a point nucleus was used and a nuclear size correction was needed only for the $1S$ level of carbon (decreases binding energy 0.45 percent).

The latest reported value of the μ^- meson mass, measured by independent means,[6] is 206.9±0.2 electron mass units.[7] The stated uncertainty does not include estimates of possible systematic errors which could be of comparable amount. We therefore conclude that an effect of the order of magnitude of the vacuum polarization is necessary for agreement with the lower limit for the meson mass ($3D-2P$ transition in phosphorus with $Z=82$ filter) measured here.

TABLE I. Upper or lower limits on the μ^- meson mass/electron mass without and with vacuum polarization correction.

Transition		Without V_p	With V_p
C: $2P-1S$	less than	209.99	208.95
P: $3D-2P$	greater than	207.67	206.89
Si: $4F-3D$	greater than	206.82	206.47

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Decay of Sb^{124}

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THERE is still some disagreement in the literature[1,2] on the interpretation of the decay of Sb^{124}. In an attempt to resolve these difficulties, the gamma radiation following the decay has been investigated in a 3 in.×3 in. NaI(Tl) scintillation spectrometer. The crystal was placed in an aluminum can, 0.005 inch thick, and mounted on a Dumont K-1197 photomultiplier. The data were taken using a 20-channel pulse-height analyzer.[3] Energy calibration was obtained from Cs^{137}, Co^{60}, and Y^{88} gamma rays. The spectrum obtained is shown in Fig. 1. For purposes of subtraction, the Compton distributions from the gamma rays at 2.11, 1.71, and 1.38 Mev were constructed from gamma radiation from Pr^{144} (2.18 Mev), Y^{88} (1.85 Mev), and Na^{24} (1.38 Mev). Relative intensities of the gamma rays (Table I) were determined from the peak areas and experimentally determined peak-to-total efficiency data for this crystal and geometry. Lower-energy gamma rays (<0.6 Mev) were looked for with techniques which eliminated most of the back-scatter peak at pulse height 90, but no indication of other gamma rays was found.

From the intensities and energies of the gamma rays and from the previously reported beta-ray analysis,[1] a consistent decay scheme may be proposed (Fig. 2). The ratio of the sums of the intensities of the gamma