linearity of the curve within 150 kev of the end point is in accordance with theoretical expectations. The "fillet" near the end point can be accounted for by the angular window of the spectrograph. The extrapolated end point of this spectrum was used along with Q_2 to calculate Q_2'.

The curves obtained from reaction (3) are shown in the insert in Fig. 1. Both the doubly ionized He^4 and He^3 ions were detected and both groups were used in the energy determination. The reaction was studied at 742- and 1237-kev bombarding energy.

In the calculations, the midpoint of the front edge of the peaks was taken as corresponding to particles leaving the front surfaces of the target at the mean entrance angle of the spectrograph. Small corrections for relativity and surface layers have been made in each case. The errors were calculated by compounding the estimated systematic errors with the observed statistical errors which were very small. The probable systematic errors assumed were 0.3° in the angle of observation, 0.3 percent in observed energy, and 0.2 percent in the bombarding energy.

Q_1 is found to be 2.121 ± 0.012 Mev, Q_2 is 0.558 ± 0.003 Mev, while Q_3 is 4.017 ± 0.022. These are both somewhat higher than the measurements of Rosario,[5] and Perlow.[6] Q'_2 is 89 ± 5 kev, which is to be compared with Hemmendinger's value of 102 ± 10 after his value is corrected for the gamma-ray recoil.[7] A combination of the above Q values with those of $D(dp)H^3$ and $D(dn)He^3$, which have Q-values of 4.036 ± 0.022 Mev and 3.265 ± 0.018 Mev, respectively,[8] and the binding energy of the deuteron, 2.237 ± 0.007 Mev[9] makes it possible to calculate the energy release in the reactions $Li^6(nH^3)He^4$ and $Be^9(\gamma n)Be^8$. We find for the first reaction $Q=4.788\pm0.023$ Mev and for the second, $Q=-1.679\pm0.008$ Mev. The ratio of the Q-value of $H^2(\gamma n)H^1$ to that of $Be^9(\gamma n)Be^8$ is 1.332 ± 0.010, which is in agreement with the measurement of Waldman and Miller[10] who find 1.338 ± 0.004. The recently determined ranges of the particles in the Li^6 reaction[11] give the following two points on the range energy relations: 0.912-Mev protons have a range of 2.00 ± 0.02 cm and 2.058-Mev alpha-particles have a range 1.04 ± 0.02 cm in air at N.T.P.

We should like to thank Mr. Robert G. Thomas for his help in obtaining the data on beryllium. This work was assisted by the joint program of the ONR and the AEC.

* Fluxmeter readings are proportional to the (charge)/(momentum) of the observed particles.

** The particles and residual nuclei produced in a reaction at a given angle have approximately the same momentum. Hence, the ions of the two products with the same charge overlap in a momentum analysis made by a magnetic field. This is quite different than in an analysis by range measurements.

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A Revaluation of the Gamma-Radiations from Co^{60} and Zn^{65}

ERLING N. JENSEN, L. JACKSON LASLETT, AND WILLIAM W. PRATT
*Institute for Atomic Research and Department of Physics, Iowa State College, Ames, Iowa**
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IN a recent paper[1] we described briefly the construction of an iron-free magnetic lens spectrometer and discussed the character of the corrections to be applied to gamma-ray measurements made with an instrument of that type. Energy values for the gamma-radiations from Co^{60} and Zn^{65}, obtained by measurement of photoelectric conversion lines, were reported. Calibration of the spectrometer was effected through the use of photoelectrons produced by annihilation radiation and of conversion electrons from ThB (F-line).

It has since become possible for us to obtain sources which would permit comparative measurements of the internal conversion line corresponding to the 2.62 Mev gamma-ray of ThC″ and the F-line from ThB. Such a comparison was considered desirable, since it would afford a definitive check of the presumed proportionality between the focused momenta and the currents in the spectrometer. Upon learning from Dr. T. Lauritsen that spectrometer work[2] at the California Institute of Technology indicated energies for the Co^{60} gamma-radiations approximately 15 kev higher than those cited by us,[1] we undertook to perform this check of our instrument *in conjunction with* a remeasurement of the photoelectric conversion lines from Co^{60}. This work has confirmed the linearity of the instrument but has led to a revised value of the spectrometer constant which is almost one percent greater than that found in our earlier work.

Based on momentum values of 1385 and 10,000 gauss-cm for the internal conversion electrons from ThB and ThC″, respectively,[3] and with the corrections for the photoelectric radiator made in the manner previously described,[1] our recent measurements lead to energies of 1.16_9 and 1.33_1 Mev for the gamma-radiations from Co^{60}. It is believed that these new values are more reliable than those given by us previously, as the stability of the spectrometer has been improved since the earlier data were obtained. These revised values are consistent with those determined by Hornyak *et al.*,[2] and with the precision wave-length measurements which have now been reported by Lind, Brown, and DuMond.[4] The values we have now obtained, when used in conjunction with previously reported[5] data obtained from a *composite* source in which *both* Co^{60} and Zn^{65} activities were present, leads to a revised value of 1.11_8 Mev for the Zn^{65} gamma-ray.

It should be mentioned that our corrections for the energy loss experienced by the electrons in the photoelectric converter are based[1] on the *average* energy loss by collision and, in the energy range with which we are concerned here, disregard complicating scattering effects. It is understood that the results of a more elaborate analysis have been used in the work of Hornyak *et al.*,[2] and lead to corrections appreciably smaller than those which we have been led to apply.

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Ferro-electric Properties of WO_3

B. T. MATTHIAS
Bell Telephone Laboratories, Murray Hill, New Jersey
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WE have recently grown single crystals of WO_3 and have found that these crystals appear to show ferro-electric behavior. The crystal structure of WO_3 may be looked at as being similar to a perovskite structure with the omission of the cations at the cube corners of the unit cell. That is, we may view WO_3 as derived from $BaTiO_3$ by the complete omission of the Ba-ions and the substitution of W for Ti. The ionic radius[1] of W^{+6} is 0.62 A and we therefore see that the WO_6 octahedra obey the empirical rule for the occurrence of ferro-electricity in perovskite-type structures

which we reported in an earlier communication in connection with the discovery of several ferro-electric columbates and tantalates.[2]

The crystals as grown from very pure tungstic acid vary in color from dark yellow to green. They are triclinic and show a marked domain structure very similar to that of ferro-electrics in the perovskite crystal system.

In the case of WO_3, however, the differences of lattice constants in different directions amount to about 5 percent whereas in the perovskite system they are near 1 percent. With a small external pressure the entire domain pattern in WO_3 can be shifted or changed, without damage to the crystal. Consequently the crystals appear to be very soft, nearly plastic.

The electric conductivity of the single crystals at room temperature is extremely high, which may have some connection with the occurrence of coloration in the crystals. It is not clear whether the color is due to slight chemical reduction or Na impurities. Pressed samples fired at much lower temperatures retained their light color and gave comparatively small losses and dielectric constants of the order of 10^3.

Dielectric measurements on the single crystals can be easily made, however, at liquid air temperature. There the losses are small and no longer interfere with the dielectric measurements. Preliminary results indicate a hysteresis loop and a dielectric constant between 100 and 300. This value is high compared to other ferro-electrics at the same temperature.

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On the $\gamma-\gamma$-Angular Correlation in Pd^{106}

DANIEL S. LING, JR.
University of Kansas, Lawrence Kansas
AND
DAVID L. FALKOFF
University of Notre Dame, Notre Dame, Indiana*
June 20, 1949

MEASUREMENTS of $\gamma-\gamma$-correlations in excited states of Ni^{60}, Ti^{46}, Mg^{24}, Ba^{134}, Sr^{88}, and Pd^{106} have been reported by Deutsch and co-workers. Of these, all but Sr^{88} and Pd^{106} can be satisfactorily fitted with theory[2] by assuming that the γ-rays are either pure dipole or quadrupole radiation and by assigning to the nuclear states involved spins consistent with such other information as is available from measurements on internal conversion or β-decay. In general, the angular correlation theory by itself is not sufficient to make any unique assignment of multipole orders or of nuclear quantum numbers.

We have developed[3] the extension of the theory of $\gamma-\gamma$-angular correlations for the case in which one of the transitions is a mixture of magnetic dipole and electric quadrupole radiation and the other either pure dipole or quadrupole radiation. With it one can explain the observed correlation in Sr^{88} which could not be explained by assuming pure multipole transitions. The discussion of this and the interference effects accompanying such mixtures will be given elsewhere.[4] We discuss here some consequences of the application of this theory to the experimental data on the $\gamma-\gamma$-angular correlation in Pd^{106}. These data seem quite reliable having been independently reproduced by Deutsch and Wiedenbeck[5] with and without a strong applied magnetic field.

Pd^{106} being an even-even nucleus, its ground state may be taken as having zero spin. Because of the $\cos^4\theta$-term in the measured correlation function, neither transition can be pure dipole. A mixture of dipole and quadrupole radiation in one or both transitions would still be consistent with this $\cos^4\theta$-dependence. However, such mixtures are allowed only when $\Delta J=0, \pm 1$. Since quadrupole radiation is forbidden for $0\rightarrow 0$ or $0\rightarrow 1$ transitions and we have already ruled out pure dipole transitions, the least possible spin for the intermediate state must be $J=2$, and this choice would force pure quadrupole radiation for the lower transition. Similarly, for the upper (initial to intermediate state) γ-transition, the lowest multipoles possible are either pure quadrupole or a mixture of electric quadrupole and magnetic dipole. Deutsch[1] has already pointed out that the data cannot be fitted when both transitions are pure quadrupole. Since the assumption of a mixed transition made possible good agreement with experiment in the case of Sr^{88}, we attempted to interpret the data for Pd^{106} with a dipole-quadrupole mixture for the upper transition, the lower transition being taken as pure quadrupole. We find that agreement with experiment cannot be obtained. It follows, therefore, subject only to the reasonable assumption that the ground state has spin zero, that at least one of the successive rays must be of octupole or higher order.

A proposed disintegration scheme for Pd^{106} and its parent Ru^{106} has been given by Peacock.[6] Our arguments, while limiting the possible multipole orders of the γ-rays, do not otherwise affect his decay scheme except to exclude $J=1$ for the intermediate state in Pd^{106}.

This example illustrates the value of the angular correlation theory for nuclear spectroscopy, but it also makes clear the need for extending the calculations to higher multipoles

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The Magnetic Susceptibilities of Some Tetravalent Uranium Fluorides*

NORMAN ELLIOTT
Brookhaven National Laboratory, Upton, Long Island, New York
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THE magnetic susceptibilities of UF_4, KUF_5, K_2UF_6, and Na_3UF_7 have been measured by the Gouy method over a temperature range of approximately 74°K to 300°K.

UF_4 was prepared from UO_2 by treatment with anhydrous HF. The complex salts were prepared by the fusion of UF_4 with stoichiometric quantities of the alkali or alkaline earth fluorides. This was done in a platinum crucible in an HF atmosphere, as described by Zachariasen.[1] Observation through a microscope showed them to be homogeneous. Uranium analyses were carried out on all the salts.

The susceptibility measurements were made over a two-month period on three or more samples of each compound, and during that time remained sensibly constant. If structural changes were taking place in any of the compounds, which might well be the case when one considers the method of preparation, this was not revealed by an effect on the susceptibilities.

With the exception of K_2UF_6, these substances obeyed the Curie-Weiss law $\chi=C/(T+\theta)$ over the whole temperature range of the investigation. K_2UF_6 followed the Curie-Weiss law down to 198°K, but deviated below this temperature. At 76°K its susceptibility is 8.6 percent smaller than that given by the Curie-Weiss equation. The experimental data are given in Table I.

The tetravalent uranium ion is thought to contain two $5f$ electrons, and so be in a $^3H_4$ state. The theoretical moment for a free ion in this configuration has been calculated by Van Vleck[2] to be 3.58 Bohr magnetons. It is seen from the table that the experimentally calculated moments are reasonably close to this value.