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.

[1] Pauling and Goldschmidt.
[2] B. T. Matthias, Phys. Rev. **75**, 1771 (1949).

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

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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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[1] E. L. Brady and M. Deutsch, Phys. Rev. **72**, 870 (1947); **74**, 1541 (1948); M. Deutsch and F. Metzger, Phys. Rev. **74**, 1542 (1948).
[2] D. R. Hamilton, Phys. Rev. **58**, 122 (1940).
[3] D. S. Ling and D. L. Falkoff, Phys. Rev. **74**, 1224 (1948).
[4] Phys. Rev. in preparation.
[5] M. Deutsch and M. L. Wiedenbeck, private communication
[6] W. C. Peacock, Phys. Rev. **72**, 1049 (1947).

The Magnetic Susceptibilities of Some Tetravalent Uranium Fluorides*

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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.