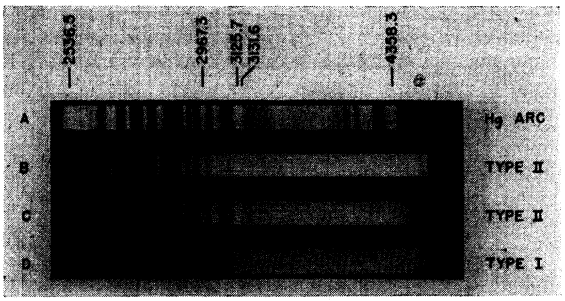

FIG. 1. Spectral transmission of Type-I and Type-II diamonds. A. Mercury spectrum from H-4 lamp. B. Transmission of Type-II diamond (borrowed from Bureau of Standards). C. Type-II diamond (NRL). D. Type-I diamond.

strated the phenomenon of crystal counting in AgCl, experimented unsuccessfully with a diamond of gem quality. Curtiss and Brown[2] recently examined 100 industrial diamonds out of which only two responded well to gamma-rays. This experience has since been duplicated at this and other laboratories. In the experiments reported thus far no comparisons of other physical properties of counting and non-counting diamonds were included.

The existence of two types of diamonds, one much rarer than the other, was described by Robertson, Fox, and Martin, in 1934.[3] The rarer type, which they designated Type II, is characterized by transparency in the ultraviolet down to λ2250, and in the infra-red at 8μ. Type I, the common variety, is opaque below λ3000 and also at 8μ. Among all the physical properties examined by Robertson and his colleagues, the most striking difference between the two diamond types was this greater optical transparency of the rare Type II. Type II also exhibited much greater photo-conductivity and was more nearly optically isotropic. As evidence of the rareness of Type-II diamonds, they remark that, following the discovery of their first Type-II diamond, between two and three hundred diamonds were examined without another being found transparent in the ultraviolet. We have examined a number of counting diamonds, sorted out of a collection of industrial diamonds at this laboratory and one borrowed from L. F. Curtiss of the National Bureau of Standards, for transparency in the ultraviolet. The diamonds were also tested here for their counting characteristics. The amplitude of the largest pulses in Curtiss' diamond was about 50 microvolts,[2] which was roughly 10 times background noise as observed without equipment; those in the best NRL diamond were only 5 times background.

Figure 1 shows the mercury line spectrum of an H-4 lamp, together with the spectral transmission of the two best counting diamonds and the corresponding transmission of a non-counting diamond, which was typical of ten examined. The ten non-counting diamonds each showed a similar abrupt absorption below λ3000, whereas, the two best counting diamonds transmitted well below λ2536. Two relatively poor counting diamonds showed correspondingly faint transmission in the ultraviolet, beyond the limit exhibited by non-counting diamonds. From this correlation between counting and ultraviolet transparency, it appears that the counting characteristic is another exclusive property of the Type-II diamond.

[1] P. J. Van Heerden, *The Crystal Counter* (Dissertation, Utrecht 1945).
[2] L. F. Curtiss and B. W. Brown, Phys. Rev. **72**, 643 (1947).
[3] R. Robertson, T. J. Fox, and A. E. Martin, Phil. Trans. Roy. Soc. London **463**, 232(A) (1934).

The Beta- and Gamma-Spectra of Ga^{72} *

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November 26, 1947

THE beta- and gamma-spectra of Ga^{72} have been investigated with a thin lens spectrometer. The results are given in Table I where a parenthesis means that the line intensity is so close to the statistical fluctuations that its existence is not certain. The energies are accurate to better than two percent, while the relative intensities are probably accurate to twenty percent except for the two highest energy beta-ray groups and the very weak gamma-ray lines. The large uncertainty in the intensities of the two highest energy beta-particle groups arises from the assignment to these groups of the particles associated with an additional apparent end point at 1.48 Mev with an apparent abundance of 10.5 percent. The intensity of the most intense gamma-ray line (0.84 Mev) has been arbitrarily taken as 100 percent in the table. The four most intense gamma-ray lines have been previously reported.[1-3] The four beta-ray groups are in qualitative agreement with the absorption results of Siegel and Glendenin.[4]

Although a complete decay scheme cannot be given on the basis of these spectra, the four most intense gamma-ray lines can be assigned with very little uncertainty as shown in the accompanying partial decay scheme (see Fig. 1). The assignment of the 0.84-Mev gamma-ray to a position in series with all or nearly all of the transitions is necessitated both by its very high intensity and by the value of 2.6 Mev of gamma-ray energy per beta-particle given by Barker,[5] which is in good agreement with the beta-ray energies and intensities of Table I, provided the 1.48-Mev group is not considered real. The four weak gamma-rays probably all help to make up the fourteen percent discrepancy between the 0.64-Mev beta-ray group and the 2.51-Mev gamma-ray line. Considering energy alone the

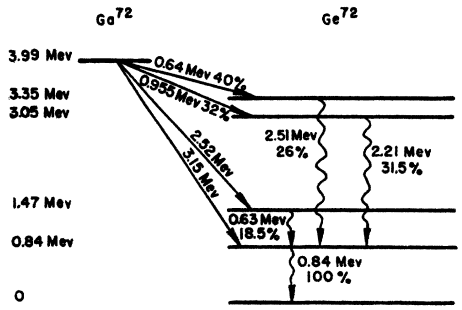

FIG. 1. A partial decay scheme of Ga^{72}.

TABLE I. Gamma-ray spectra of Ga^{72}.

Ga^{72} beta-groups		Ga^{72} gamma-rays	
Energy	Intensity	Energy	Intensity
3.15 Mev	9.5 to 20%	2.51	26%
2.52 Mev	8 to 18.5%	2.21	31.5%
0.955 Mev	32%	1.87	7.5%
0.64 Mev	40%	(1.60)	(4.5%)
		1.05	4.5%
		0.84	100%
		0.68	2%
		0.63	18.5%

1.87-Mev line fits well between the levels of Ge^{72} at 3.35 Mev and 1.47 Mev, while the sum of the other three lines, $0.68+1.05+1.60=3.33$, is very close to the difference between the 3.35-Mev level of Ge^{72} and the ground state. However, the intensity of the 0.68 line appears to be much too small to be in a sequence with the 1.05-Mev line and probably the 1.60-Mev line, even allowing for rather large uncertainty in intensity measurements.

The 0.68 line was found by means of its conversion electrons which appear in about 0.5 percent of the disintegrations. The gamma-ray line intensity is so small as to be very difficult to measure. It would appear, however, that the conversion coefficient was between 10 and 50 percent which, for such a high energy and such a low atomic number, would indicate a metastable level with a considerable half-life. The decay period of the beta-ray spectrum and conversion line differs inappreciably from 14.1 hours, indicating that the delay of the line is not longer than a few hours at most.

* This document is based on work performed under Contract No. W-35-058-eng-71 for the Atomic Energy Project at the Clinton Laboratories.

[1] C. E. Mandeville, Phys. Rev. 64, 147 (1943).
[2] L. C. Miller and L. F. Curtiss, Phys. Rev. 70, 983 (1946).
[3] A. Wattenburg, Phys. Rev. 71, 497 (1947).
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Stark Spectrum of HDO*

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THE $5_{3,3;0}$–$5_{3,2;1}$ rotation line of HDO[1] has been measured in the 1.25-cm region at a frequency of 22,307.67 ±0.05 mc/sec. The Stark spectrum of this line was studied in a wave-guide cell by use of equipment and methods that have been described previously.[2–4] Five components were detected, but only three of them were measured. Line breadths were of the order of 250 kc/sec. and, qualitatively, intensities followed theoretical predictions, i.e., proportional to M^2.

In Fig. 1 is plotted the experimental data for the three Stark components that were measured. The data may be fitted with the formula:

$$\Delta\nu = 9.00E^2M^2\times10^{-8}\ \text{mc/sec.},$$

where E is measured in volts per cm and M is the magnetic quantum number, $|M|\leq 5$.

In deriving this equation theoretically, the calculation

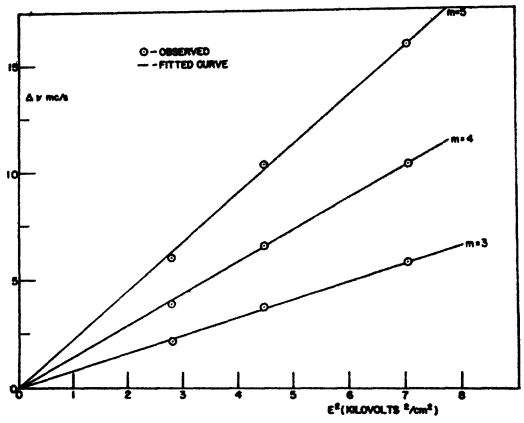

FIG. 1. HDO Stark pattern.

turned out to be considerably more straightforward than expected for an asymmetric rotor. Most of the energy denominators in the second-order terms of conventional perturbation theory are in the infra-red and can be neglected in comparison with the line $5_{3,3;0}$–$5_{3,2;1}$. The largest neglected term corrects the simplified formula in two ways: (*a*) The entire Stark pattern is shifted toward the undisturbed line by an amount about 2.5 percent of its total width. (*b*) The term in M^2 is increased by about 2 percent. The contribution of all the other terms is negligible. For HDO, $K=-0.7$ so that in calculating the direction cosine matrix elements an additional approximation was made by using the symmetric rotor wave functions without further transformation. This approximation involves an error of less than 2 percent of the total Stark pattern width. The resulting theoretical formula is:

$$\Delta\nu=\frac{\mu^2E^2\sin^2\delta M^2}{h^2(\nu_{5,1}-\nu_{5,0})}\frac{1}{50},$$

where: μ=dipole moment in e.s.u.-cm, δ=angle between ellipsoid of inertia and dipole moment=20°38′,[5] E=applied electric field in e.s.u./cm, ν=frequency in c.p.s.

By using the dipole moment of $H_2O(1.84\times10^{-18}$ e.s.u.-cm),[6] the above equation becomes

$$\Delta\nu=9.56\times10^{-8}E^2M^2\ \text{mc/sec.},$$

which is to be compared with the experimental formula.

The agreement is reasonable since, in fact, the dipole moment of HDO can only be approximated by that of H_2O. Using the experimental formula, the value of the dipole moment of HDO obtained, is:

$$\mu=1.78\pm0.06\times10^{-18}\ \text{e.s.u.-cm.}$$

Errors in field strength constitute about 1.5 percent of the indicated error.

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** Socony-Vacuum Laboratories, Paulsboro, New Jersey.
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[4] B. P. Dailey, Phys. Rev. 72, 84 (1947).
[5] G. W. King, R. M. Hainer, and P. C. Cross, Phys. Rev. 71, 433 (1947).
[6] See, for example, "Tables of electric dipole moments," Tech. Report No. II, Laboratory for Insulation Research, Massachusetts Institute of Technology.

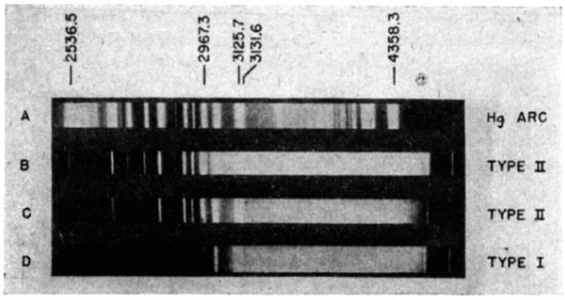

FIG. 1. Spectral transmission of Type-I and Type-II diamonds. A. Mercury spectrum from H-4 lamp. B. Transmission of Type-II diamond (borrowed from Bureau of Standards). C. Type-II diamond (NRL). D. Type-I diamond.