FIG. 2. Two-crystal spectrometer applied to the study of low angle x-ray diffraction.
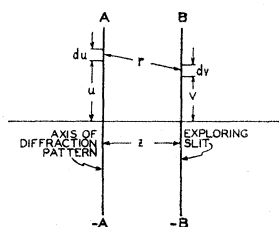

FIG. 3. Geometry of elongated diffraction patterns.

that another method of study of low angle x-ray diffraction utilizing the two-crystal spectrometer might also be successful. In Fig. 2, the arrangement is shown schematically. A "rocking curve" with the crystals in the "parallel position" is to be observed first *without*, then *with* the sample in place. The *difference* between the two curves should give the low angle x-ray diffraction pattern. Here again, however, the rays diverge in the direction normal to the figure.

The diffraction patterns obtained in both cases require a correction, as A. Guinier has pointed out,[3] in order to interpret them as the radial distribution of intensity or halo that the sample would give if the primary beam were a fine parallel pencil such as to form a sharp point in the center of the halo. Both the experimental arrangements described give instead of this an intensity distribution which is essentially a superposition of many such circular halos with their centers uniformly and continuously distributed along a straight line. The purpose of this note is to give a method for correcting the curves of the latter type so as to obtain the true radial intensity distribution which generated them.

In Fig. 3 the line $-AA$ is the line of centers along which the circular diffraction halos are considered to be uniformly spread. $-BB$ is the slit which explores across the resulting linear pattern spread to left and right of $-AA$. What is observed is the intensity $\Phi(z)$ integrated over the variables u and v, and plotted as a function of z. What is desired, is the radial intensity distribution $\phi(r)$ in an elementary circular halo. The problem is simplified by discussing it in terms of $F(z^2)$ and $f(r^2)$, where $F(z^2) = \Phi(z)$ and $f(r^2) = \phi(r)$. From Fig. 3, $r^2 = z^2 + (u-v)^2$. The situation is expressed as

$$F(z^2) = \int_{-A}^{A} \int_{-B}^{B} f[z^2 + (u-v)^2] du\, dv. \qquad (1)$$

In this integral equation F is given and f is sought.[4] When the limits A and B are "infinite," that is to say when the

height of the diffraction pattern and the exploring slit (or its equivalent) are each large compared to the width of the pattern along the z-axis,[5] the solution for (1) is

$$f(p) = -\frac{1}{2\pi B} \int_{p}^{\infty} F'(q) \frac{dq}{(q-p)^{\frac{1}{2}}}; \qquad p = z^2. \qquad (2)$$

(No method of solving this equation is known at present when the limits are finite.) The solution (2) involves operations all of which can be performed on observed diffraction curves F without the necessity for translating these into analytically expressed functions. The observed curve $\Phi(z)$ is replotted as $F(q)$, and its derivative $F'(q)$ is found by constructing tangents. A set of curves, each the product of $-F'(q)$ into the curve $(q-p)^{-\frac{1}{2}}$, is then formed for a series of appropriately selected values of p along the abscissa q, and the areas under each of these from p to ∞ (obtained by planimeter or otherwise) give the ordinates of $f(p)$. The author is much indebted to Dr. Robert Serber of the University of California for the method of inverting this integral equation.

[1] A. Guinier, Ann. de physique 12, 161 (1939).
[2] The author has heard indirectly that I. Fankuchen has been working on a similar method though its details are unknown to him.
[3] The correction for the special case of a Gaussian distribution, as Guinier has shown, amounts merely to a change in the normalizing factor, but no method heretofore was known for the general case.
[4] F and f do not have the same dimensions. f is the power per unit area in the diffraction pattern per unit length of line, $-AA$. F is the power per unit width of slit, $-BB$. Thus dimensionally $f = [\text{Power} \cdot L^{-3}]$; $F = [\text{Power} \cdot L^{-1}]$.
[5] These qualifications are inserted to minimize end effects due to changes in pattern intensity at the termini. This is best accomplished if B is less than A by an amount at least equal to the radius of the pattern $\phi(r)$ over which appreciable intensity is present.

First-Order Stark Effect in the Microwave Spectrum of Methyl Alcohol

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HERSHBERGER and Turkevitch[1] report having found a series of five lines in the microwave absorption spectrum of methyl alcohol.

The methyl alcohol spectrum in this region has now been investigated in this laboratory using the microwave spectrograph recently described.[2] Twenty-four spectral lines have been observed. The Stark effect of these lines was observed using a square wave to modulate the absorption in the gas instead of the sine wave previously employed.[2] This modification was suggested and the amplifier used was constructed by Mr. Robert Karplus. Following this procedure the original spectral line and its resolved or unresolved Stark components, shifted in frequency by the field, were observed simultaneously on the oscilloscope screen. Frequency differences among components of the spectral pattern were measured by the method of Good and Coles.[3]

The Stark effect served to divide the spectral lines into two groups. The lines of series III were observed at a field level of only 30 volts/cm. The remaining lines required modulating fields of 300 volts/cm and higher. The series III lines had symmetric Stark patterns, and the Stark

TABLE I. Microwave spectrum of methyl alcohol.

Mc	Shape of Stark pattern	Minimum modulating voltage, v/cm	Series
20,898	unsym	300	I
20,989	unsym	300	I
21,551	unsym	300	I
22,095	unsym	300	I
23,033	unsym	300	I
25,385	unsym	300	I
24,040	unsym	300	II
24,081	unsym	300	II
24,317	unsym	300	II
25,050	unsym	300	II
24,928.8	unsym	30	III
24,954.6	sym	30	III
25,017.8	sym	30	III
25,132.0	sym	30	III
25,300.3	sym	30	III
25,546	sym	30	III
25,796	unsym	30	III
25,898	sym	30	III
26,310	sym	30	III
26,562	sym	30	III
23,121	unsym	300	—
23,415	unsym	300	—
23,450	unsym	300	—
23,861	sym	30	—

effect of the line at 25,126 Mc fitted the following formula

$$\Delta\nu = 0.084E,$$

where $\Delta\nu$ is the frequency separation of the unsplit line and one of its two shifted Stark components (or groups of unresolved components). The separation $\Delta\nu$ is in megacycles, and E is in volts/cm. The Stark patterns of the other lines were unsymmetric and for the line at 23,121.8 Mc $\Delta\nu$ was 3.84 Mc for a field of 504 volts/cm.

The experimental data are summarized in Table I. Frequencies given to six figures were obtained using lines of the $N^{14}H_3$ and $N^{15}H_3$ spectrum as secondary standards; other frequencies were obtained using a calibrated wavemeter and are good to ± 5 Mc.

The rotational constants of methyl alcohol have been obtained from infra-red data by Borden and Barker.[4] They may be used with the appropriate selection rules to predict some of the features of the methanol spectrum in the microwave region. The transition $\Delta J = +1$, $\Delta K = 0$, as pointed out by Hershberger and Turkevitch,[1] would give frequencies of 48,700 Mc and higher. For $\Delta J = 0$, $\Delta K = +1$ we should expect frequencies in the far infra-red. For $\Delta J = \pm 1$, $\Delta K = \pm 1$ it is possible to place only two or three lines in this region of frequency, and their separations should be irregular. This is also true for transitions between the degenerate K levels split by the slight asymmetry of the molecule.

Koehler and Dennison[5] have calculated the energy levels for methyl alcohol considered as two coupled symmetric rotors whose mutual rotation is hindered by a potential function having a triple minimum. One or perhaps two transitions between the levels for $n = 0$ ($n =$ torsional vibration quantum number) should fall in the K-band. It seems likely that each of these transitions should be split by centrifugal distortion into one or more series of lines characterized by different values of J and K.

It seems unlikely that a fine structure due to free rotation is being observed, since the spacing of the levels is much too dense for the large values of the rotational constants of OH and CH_3 found by Borden and Barker.

I would like to thank Professor E. Bright Wilson, Jr. for his encouragement and many helpful suggestions during the course of this investigation.

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The 5.3 Day Isotope in Element 61

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A SAMPLE of element 61, formed by fission and shown by mass spectrographic analysis to be predominantly mass 147 (61 isotopes of other masses were present to less than one part in two thousand), was irradiated by slow neutrons in the Clinton Pile. After bombardment, a 5.3-day activity was found to be present in the element 61. The cross section for this reaction was approximately 60×10^{-24} cm^2. The radiations from this sample, as determined by absorption curves, were a beta-ray of approximately 2.5 Mev, and a gamma-ray of approximately 0.8 Mev. This is probably the same activity observed by Law, Pool, Kurbatov, and Quill.[1,2] They observed it as formed by $Nd(p, n)$, $Nd(d, n)$, and $Nd(\alpha, p)$. The second of these reactions is incompatible with our determination of the mass of this isotope.

To verify that the reaction involved was actually (n, γ) and hence that the mass of the 5.3-day active isotope in element 61 was 148, a portion of the sample was analyzed by means of a mass spectrograph.[3] After separation, active isotopes were found at masses 147 and 148. To verify that the activity at mass 148 had a half-life of 5.3 days, the following technique was used: The photographic plate upon which the separated isotopes were deposited was placed successively against various parts of a larger photographic plate for times calculated to give equal intensity in the 148 position if its half-life were 5.3 days. Five exposures were taken for successive times of 33.2 hours, 40.7 hours, 52.3 hours, 72.3 hours, and 122 hours. Upon development this large plate showed equal blackening at mass 148 and increasing blackening for successive transfers at mass 147. Thus the active isotope in element 61 with a half-life of 5.3 days is at mass 148.

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