the total cross section of the double Compton process due to the behavior near $\nu''=0$. This physically absurd result makes it clear that the large cross section for low frequency ν'' is obviously caused by a faulty application of the theory.

The present case of infra-red catastrophe appears to us particularly interesting because it seems likely that the deviation from the Klein-Nishina formula due to multiple processes may be measurable for hard gamma-rays passing through matter of low atomic number. Although every higher step adds a factor of 137 in the denominator of the cross sections, still the numerical factors present seem to make an observable effect not unlikely once a proper cut-off frequency has been determined.

We hope to report on our calculations in detail in the near future.

[1] C. J. Eliezer, Proc. Roy. Soc. **A187**, 210 (1946).
[2] W. Heitler, *Quantum Theory of Radiation* (Oxford, 1936), paragraph 18.

Magnetic Fields of Astronomical Bodies

Horace W. Babcock
Mount Wilson Observatory, Pasadena, California
June 7, 1947

On the assumption that magnetic fields in stars of approximately equal mass are proportional to their rates of rotation, I predicted early in 1946 that fields of the order of 1500 gauss should occur in certain early-type stars, and that the integrated Zeeman effect resulting from such stellar fields should be observable under certain conditions. Observations of 78 Virginis beginning in April of the same year, have confirmed this prediction,[1] and fields of the same general order of magnitude have since been observed in other stars. The strongest field observed to date is that of the peculiar A-type star BD—18°3789 (HD 125248); measures from two plates give a polar field of 5500 gauss. The polarity is opposite to that of 78 Virginis. I have been able to show further that, within the uncertainties of the observations, *the magnetic dipole moments of the earth, sun, and 78 Virginis* (8×10^{25}, 8×10^{33}, and 4×10^{36} gauss cm^3, respectively) *are proportional to their angular momenta* and may be obtained by multiplying the angular momenta, in c.g.s. units, by 10^{-15} gauss cm sec. g^{-1}. A paper discussing this and some other aspects of magnetism in astronomical objects is in press.[2]

If the foregoing relationship is of real physical significance, it may possibly apply also to the galaxy, and this is of some interest, partly on account of the influence of magnetic fields on cosmic rays. Actually, it is easier to apply it to our nearest neighboring galaxy, the Andromeda Nebula (M31), which, converging evidence shows, is essentially a twin of our own, and for which the rotation and mass have been measured more directly by spectrographic observation.[3] From the same measurements, we know that the greater part of the mass of M31 lies far from its center, and that to a first approximation we may regard it as a rather thin disk of uniform density rotating with a nearly constant angular velocity of 2.5×10^{-15} rad/sec. Its mass, a major portion of which must be dark material, is calculated to be 1×10^{11} times that of the sun; and the effective radius, within which lies most of the mass, may be taken as 6000 parsecs. If M31 has a magnetic moment proportional to its angular momentum, then, using the coefficient 10^{-15} gauss cm sec. g^{-1}, the moment is computed to be of the order of 10^{59} gauss cm^3, corresponding to a field of about 10^{-8} gauss parallel to the axis. Within the uncertainties of our knowledge, this should apply almost as readily to our galaxy as to the Andromeda Nebula.

It is probably unnecessary to add that the computed result for M31 is meaningless unless it is granted that the proportionality of magnetic moment to spin is a universal law, and that it is applicable to an assemblage of stars and dust in revolution as well as to single stars in rotation. Chapman[4] has objected to the view that terrestrial and solar magnetism are fundamental on the ground that the magnetic axes are inclined to the axes of rotation by about $11\frac{1}{2}$ degrees and 6 degrees, respectively, and that since at least a moderate component of the field seems not to be due to spin, it may be regarded as unlikely that any part of the field is due to a cause fundamentally related to gravitation.

[1] H. W. Babcock, Ap. J. **105**, 105 (1947).
[2] H. W. Babcock, Pub. Astro. Soc. Pac. **59**, 112 (June 1947).
[3] H. W. Babcock, Lick Observatory Bulletin **19**, 41 (1939).
[4] S. Chapman, Nature **124**, 19 (1929).

Method of Correcting Low Angle X-Ray Diffraction Curves for the Study of Small Particle Sizes

Jesse W. M. DuMond
California Institute of Technology, Pasadena, California
May 26, 1947

A. Guinier in France has had considerable success[1] in the study of small particle sizes (and even their shapes) by means of low angle x-ray diffraction utilizing the reflection-type focusing, curved crystal spectrometer to obtain a monochromatic convergent beam of x-rays. The sample whose diffraction pattern is to be studied is placed in the convergent beam about midway between the curved crystal and the focus; the geometry of the arrangement is shown in Fig. 1. In reality the convergent beam is focused

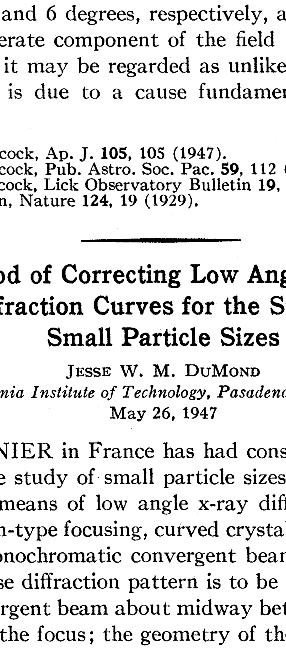

Fig. 1. Guinier's arrangement for the study of low angle x-ray diffraction.

only in the plane of the figure. The rays actually diverge in the direction normal to the plane of the figure so that in the absence of the sample a sharp spectral *line* is formed at *F*. With the sample in place a linear rather than a circular diffraction pattern is formed on the film.

It has occurred to the author, and possibly to others,[2]

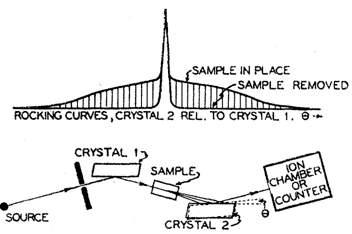

FIG. 2. Two-crystal spectrometer applied to the study of low angle x-ray diffraction.

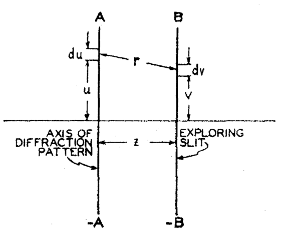

FIG. 3. Geometry of elongated diffraction patterns.

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

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

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

B. P. DAILEY*
Harvard University, Cambridge, Massachusetts
May 24, 1947

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