their transport in the field follows naturally. In the latter case, it is usually more difficult to explain how the carrier can move than it is to explain how the carrier arises.

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On the Diffuse X-Ray Diffraction Maxima Observed by C. V. Raman and P. Nilakantan

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IT has been known for a long time that Laue photographs exhibit radial streaks.[1] When the incident beam contains both characteristic and continuous x-rays diffuse spots (which are not regular Laue spots) may also be observed. These spots were first studied by G. D. Preston[2] who demonstrated beyond doubt that they were produced by the characteristic, the radial streaks by the continuous component of the incident radiation. Preston showed further that both the radial streaks and the diffuse spots increased in intensity when the temperature of the crystal was raised. His observations have later been confirmed by other investigators.[3] A year ago a theory of diffuse scattering of x-rays by crystals was developed[4] (superseding the theory of Debye and of Jauncey and Harvey, but reviving and extending earlier, long-forgotten, results obtained by Faxén[5]) and it was shown that this theory provided an explanation for the phenomenon observed by Preston and others. Lately the diffuse spots have been found also by Raman and Nilakantan[6] who, being unaware of Preston's work, at first believed that they had discovered a new effect. The most recent article by Raman and Nilakantan[7] reports on the diffuse spots observed in Laue photographs of rocksalt. In this article the statement is made that the theory of diffuse scattering does not account for their observations and it is claimed that they are dealing with a new phenomenon and not with a diffuse scattering effect. All qualitative observations reported by Raman and Nilakantan are in perfect accord with the predictions of the theory of diffuse scattering, but the authors nevertheless refuse to accept the applicability of this theory on the ground that it does not give the correct scattering angles for the diffuse spots.

According to the theory of diffuse scattering[4] the diffuse diffraction maxima correspond to

TABLE I. *Data on rocksalt (Raman and Nilakantan, reference 7),* $\lambda = 0.7095A$.

LATTICE PLANE	FIGURE	θ_i	$2\theta_m$ OBS.	$2\theta_m$ CALC.	$2\theta_B$
400	9	11° 51′	29° 5′	28° 50′	
400	11	17° 40′	29° 21′	29° 34′	
400	14	19° 26′	29° 37′	29° 44′	
400	15	25° 9′	30° 13′	30° 9′	29° 12′
420	13	12° 38′	32° 9′	32° 6′	
$4\bar{2}0$	13	13° 1′	32° 19′	32° 10′	
$\bar{4}02$	9	14° 46′	32° 29′	32° 29′	
420	15	21° 53′	33° 13′	33° 30′	32° 44′
600	14	19° 26′	43° 57′	43° 38′	
600	15	25° 9′	45° 19′	45° 16′	44° 26′

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scattering angles $2\theta_m$ given by the equation

$$\tan 2\theta_m = 2 \sin \theta_B \cos \theta_i / (1 - 2 \sin \theta_B \sin \theta_i), \quad (1)$$

where θ_i is the glancing angle of incidence, θ_B the Bragg angle. When $\theta_i - \theta_B$ is small Eq. (1) becomes

$$2\theta_m = 2\theta_B + 2(\theta_i - \theta_B) \sin^2 \theta_B. \quad (2)$$

Raman and Nilakantan maintain that the scattering angles for the diffuse maxima are just the Bragg scattering angles $2\theta_B$ and hence that they are not given by Eq. (1). The differences $2\theta_m - 2\theta_B$ are small for all diffuse spots which are sufficiently intense to permit measurement and it is consequently necessary to know the distance from crystal to photographic plate with some accuracy. It is not clear from Raman and Nilakantan's article whether this distance was carefully determined for each separate photograph. The regular Laue spots are well defined and they can conveniently be used to calibrate the various Laue diagrams, whether they be the original photographs or reproductions.

In order to verify or disprove the statement made by Raman and Nilakantan the Laue photographs reproduced in their article have been independently measured by four different individuals (the present writer being one of them) in this laboratory. Measurements were made both on diffuse spots and on regular Laue spots, the latter being used to calibrate the reproduced diagrams. On the basis of the average values so obtained the data given in Table I columns 3 and 4 were deduced. If we take into account all possible sources of error an accuracy of 25′ in the scattering angles can be claimed, and in some cases the greatest possible error is definitely less. The observed scattering angles differ considerably from those reported by Raman and Nilakantan, but no explanation for this discrepancy can be offered. Column 5 contains the scattering angles $2\theta_m$ calculated from Eq. (1) while column 6 gives the theoretical Bragg scattering angles (in calculating these the value $a = 5.628$A for the cube edge of rocksalt was used and the value 0.7095A was assumed to be the average wave-length of Mo$K\alpha_1$ and Mo$K\alpha_2$). It is seen from Table I that the observed scattering angles agree with those calculated from Eq. (1) well within the experimental error. On the other hand the differences between the observed values $2\theta_m$ and the calculated values $2\theta_B$ in several cases far exceed the greatest possible error in the measurements.

TABLE II. *Data on rocksalt (Preston, reference 2, Fig. 5a), $\lambda = 0.560A$.*

LATTICE PLANE	θ_i	$2\theta_m$ OBS.	$2\theta_m$ CALC.	$2\theta_B$
$\bar{4}42$	18° 45′	35° 10′	34° 59′	
442	20° 22′	35° 31′	35° 14′	34° 44′
$\bar{6}02$	17° 28′	36° 39′	36° 29′	
602	19° 35′	37° 0′	36° 55′	36° 40′
262	17° 56′	37° 55′	38° 15′	
622	18° 37′	38° 18′	38° 23′	38° 32′

For comparison Table II contains data deduced from Preston's Laue photograph of rocksalt (Fig. 5a in his article), and again Eq. (1) accounts for the observed scattering angles. Preston also investigated diffuse spots produced by monochromatic Ag$K\alpha$-radiation with aluminum crystals. The scattering angles (accurate to 10′) as reported by Preston are given in Table III. His observed values $2\theta_m$ differ from the Bragg scattering angles $2\theta_B$ by amounts greater than the experimental error, but agree with the values calculated from Eq. (1).

TABLE III. *Data on aluminum (Preston, reference 2) $\lambda = 0.560A$.*

LATTICE PLANE	θ_i	$2\theta_m$ OBS.	$2\theta_m$ CALC.	$2\theta_B$
200	0	15° 23′	15° 27′	15° 45′
311	17° 33′	26° 50′	26° 43′	26° 16′

In view of the results given in Table I there seems to be no acceptable basis for the assertion of Raman and Nilakantan that the theory of diffuse scattering is incapable of giving the correct positions of the diffuse maxima. There is thus no experimental justification for the statement that the effect described by Raman and Nilakantan (observed earlier by others) is not a diffuse scattering phenomenon.