Elimination of the Mosaic Crystal Imperfection Effect on the Width of X-Lines

ON the basis of results obtained by means of different spectroscopic methods, I wish to show that the highest attainable resolving power does not always correspond to the perfection of the crystal measured by means of the double-crystal spectrometer. High resolving power can be attained both with imperfect (mosaic) crystals and with perfect ones.

For example, in the case of crystals of sodium chloride, for the reflecting width w_c the minimum value of 87″ has been found experimentally[1]. According to this value, the width W of the copper $K\alpha_1$ line should correspond at least to 88″ (if the validity of the Gauss equation[2], $W = \sqrt{w_c^2 + D^2 w_\lambda^2}$, is assumed). According to Hoyt's equation[3], $W = w_c + Dw_\lambda$, the value of W for the copper $K\alpha_1$ line should amount to at least 102″. It will be shown here that these relations cannot be used generally.

With Prof. Dolejšek[4], I have obtained by means of the symmetrical spectrographic arrangement, in which the distance slit to crystal equals the distance crystal to photographic plate, with a crystal of sodium chloride an uncorrected value of $W = 15″$ for the true width of the copper $K\alpha_1$ line measured at half maximum of the rocking curve, which corresponds to 0·41 X.U. A similar result was obtained with the lines of molybdenum, where $W = 11″$, that is, 0·30 X.U.

This indicates that the imperfection of the sodium chloride crystals cannot in this case have any influence on the width of the lines as given by the equations referred to above. It is further evident that the values of the width of the lines obtained by us correspond to the true width of the lines of the above-mentioned elements determined by means of the double-crystal spectrometer.

These facts can be explained if two kinds of imperfection of the crystal are assumed. The first kind of imperfection is caused by the mosaic structure of the crystal, which will be designated by $\Delta\sigma$; the second one consists in an irregular arrangement of the atomic planes in the crystal, $\Delta\delta$, or in some other factors. However, it can be shown (unpublished work) when using the symmetrical spectrographic arrangement that reflection on mosaic crystals leads to an angular broadening of the line towards the short wave-lengths :

$$w_\sigma = (\Delta\sigma)^2 \cot \varphi,$$

where φ is the angle of the deflection. The broadening of the lines calculated by means of the formula given above, which holds for the crystal of sodium chloride, can be neglected for X-rays of medium wave-length. When, however, the photographic plate is shifted in the direction towards or from the crystal, so that the distances slit to crystal and crystal to photographic plate are made unequal, a broadening of the line due to the mosaic structure of the crystal is produced. From such a broadening of the line at different distances of the plate from the crystal, the value of w_c for the crystal of sodium chloride was determined, which gave a value of about 100″. If this value is substituted in the above formula, the angular broadening of the lines w_σ is 0·2″ (which corresponds to about 2 per cent of the true width of the lines copper $K\alpha_1$) at half maximum of the rocking curve. This broadening of the line $\Delta\lambda_\sigma = 0·008$ X.U. lies below the limit of accuracy attainable by the most accurate methods.

It is thus obvious that crystals with imperfect mosaic structure allow us to get the extreme resolving power when the symmetrical arrangement is used, since the broadening of the lines due to the mosaic structure is negligible.

The second kind of imperfection of the crystal (which cannot be eliminated by means of the symmetrical arrangement) is, as can be seen from our results given above, inappreciable. These facts are in agreement with the findings of Ewald and Renninger[5], which have shown that the small planes of the crystal of sodium chlorine reflect according to the perfect structure, but not according to the mosaic. Thus the influence of $\Delta\sigma$ is approximately the same as in the case of perfect crystals, that is, in the absence of the mosaic structure. According to these results, new methods for measurements of the imperfection of crystals can be worked out ; further, the equation for the physical resolving power of crystals, as given by Allison[6],

$$\frac{\lambda}{\Delta\lambda} = \frac{\tan \varphi}{w_c},$$

must be modified, putting in instead of w_c the function of w_σ and w_δ.

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[1] Kirkpatrick and Ross, P. A., *Phys. Rev.*, **43**, 596 (1933).
[2] Ehrenberg, W., and Mark, H., *Z. Phys.*, **42**, 807 (1927). Schwarzschild, M. M., *Phys. Rev.*, **32**, 162 (1928).
[3] Hoyt, A., *Phys. Rev.*, **40**, 477 (1932).
[4] Bačkovský, J. M., and Dolejšek, V., *Č. J. Mat. Fys.* **67**, No. 3 (1938).
[5] Ewald, P. P., and Renninger, M., Int. Conf. on Phys., London **2**, 57 (1935).
[6] Allison, S. K., *Phys. Rev.*, **38**, 207 (1931).

Formation of Negative Ions at Surfaces

ARNOT has described experiments[1] which he has interpreted as showing that a positive ion striking a surface can be converted into a negative ion by capture of two electrons. The negative ions drawn off may have energies in excess of that imparted to them in the accelerating electric fields. Some of this work was not in agreement with other results which one of us had obtained for negative ions, and we have therefore repeated and extended this.

Using an apparatus somewhat similar to Arnot's, but constructed entirely in a blown pyrex tube which could be degassed at high temperature, we were unable to find the negative ion of mercury once the apparatus was thoroughly clean, although initially, whilst a certain amount of impurity was present, a negative ion with approximately the mass of the Hg^- ion was found, in agreement with earlier work by Stille[2]. However, bombardment of metal surfaces in the ionization chamber, by presumably mainly Hg^+, did produce several light negative ions ($C_2H_3^-$, CO^-, etc.), and these possessed excess energy. Subsidiary experiments indicated that this energy did not come from electrical oscillations within the tube ; in particular, negative ions with excess energy could be drawn off normally from a flat plate bombarded normally with the positive ions.

These new experiments raised the question of the uniqueness of the mechanism of negative ion formation proposed by Arnot ; they seemed rather to