Primary Ionization of β-Particles in Alcohol Vapour and Argon

THE efficiency of a counter for detecting ionizing particles can be written

$$\varepsilon = 1 - \exp(-Spl/76), \qquad (1)$$

where S is the primary ionization of the particle in the gas at N.T.P., p the pressure in cm. of the contained gas at 0° C., and l the length of the path of the particle in the counter. T. Graf[1] has made use of this fact to measure the primary ionization of β-particles in air. Two counters were placed in a spectrograph so that all particles passing through the second counter had, of necessity, also passed through the first. If N is the rate of counting in the second counter and N_c the coincidence counting-rate, the efficiency of the first counter is given by

$$\varepsilon = N_c/N. \qquad (2)$$

A knowledge of l and p then enables S to be calculated from equation (1).

We have, by this method, investigated the primary ionization of β-particles in mixtures of argon and ethyl alcohol vapour. For a mixture, formula (1) can be written

$$\varepsilon = 1 - \exp\{(-S_1p_1 + S_2p_2)l/76\}. \qquad (1a)$$

S_1 and S_2 can be evaluated by determining ε for two different combinations of the partial pressures p_1 and p_2.

The experiment was performed for β-particles of one energy only, namely, 0·42 MeV., and the mean values obtained were 79·0 ion pairs/cm. in alcohol vapour and 29·8 ion pairs/cm. in argon. These are consistent with values of 68·7 ion pairs/cm. and 25·9 ion pairs/cm. respectively for β-rays of energy 1 MeV.[2].

The value for argon is in agreement with measurements made with fast cosmic rays[3].

Hazen[4], by plotting a curve of primary ion pairs/cm. against electrons per molecule for five gases and extrapolating, estimates a value of 33 ion pairs/cm. for alcohol vapour. By adding the measured values for C_2, $3H_2$ and $\frac{1}{2}O_2$, he obtains a value of 42 ion pairs/cm. On either basis the value obtained is considerably smaller than the value we have measured. Indeed, on theoretical grounds[5] the measured value of 69 ion pairs/cm. is only consistent with an effective ionization potential of 7–8 electron volts.

It is noteworthy that the efficiency of a counter containing alcohol vapour at 1 cm. mercury pressure measured by Rochester and Jánossy[6] suggests a value of at least 61 ion pairs/cm. for alcohol vapour.

If any single ion pair escapes detection in the argon-alcohol counters, the value of the primary ionization for alcohol vapour would be even greater than 69 ion pairs/cm. This type of counter is, however, likely to be 100 per cent efficient, in contrast with the slow types used in earlier work[1,7,8].

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Relations Between Structure-Factors

IF the edges of the unit cell of a crystal are all taken equal to 1, the electron-density function can be expressed as a three-dimensional Fourier series of the form

$$\rho(x,y,z) = \sum_{h=-\infty}^{\infty} \sum_{k=-\infty}^{\infty} \sum_{l=-\infty}^{\infty} F_{h,k,l} \exp\{2\pi i(hx+ky+lz)\}.$$

It is a commonplace of crystallography that X-ray diffraction methods can tell us the value of $|F_{h,k,l}|$ but never the actual phase of $F_{h,k,l}$. If we restrict ourselves to the case of a centro-symmetric crystal, we can take the F's real and so

$$F_{h,k,l} = \alpha_{h,k,l} \; |F_{h,k,l}|,$$

where the second factor on the right-hand side is known and $\alpha_{h,k,l} = \pm 1$.

Harker and Kasper[1] have recently shown that the $F_{h,k,l}$'s must satisfy certain relations of inequality, and that these relations sometimes enable one to decide unequivocally for some values of (h,k,l) whether $\alpha_{h,k,l}$ is $+1$ or -1. I have succeeded in extending these ideas and have established several large classes of inequalities between $F_{h,k,l}$'s. Applying the inequalities to the data on oxalic acid given by Robertson and Woodward[2], I have been able to determine the signs of some forty-two terms. I believe that more of the signs can be obtained directly, though I have not yet succeeded in doing so. In any event, however, these forty-two terms give a more than adequate first approximation, which can be followed up either by the usual methods or by the use of modern computing machinery.

Apart from the practical application of these ideas to the determination of phases, they also lead to some rather curious restrictions on the structure-factors. I have investigated a number of cases and have verified that these restrictions were, in fact, always satisfied, though no really adequate physical explanation of them suggests itself.

A full account of the whole subject will shortly be published elsewhere.

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[1] In a paper read at the 1947 summer meeting of the American Society for X-Ray and Electron Diffraction at St. Marguerite, Quebec.
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Meson Decay and the Theory of Nuclear Forces

IN recent observations with the photographic plate method, Lattes, Muirhead, Occhialini and Powell[1] have given direct evidence of cosmic ray mesons with two different masses; furthermore, in some of their pictures the heavier meson stops in the emulsion and emits a lighter meson. At first one is tempted to identify these two mesons with the vector and pseudoscalar ones postulated in the Schwinger mixed meson theory of nuclear forces. Wentzel[2] has, in fact, recently suggested that a vector meson can disintegrate into a pseudoscalar meson plus a photon, and one might conjecture whether this is not the process observed by the Bristol group[1]. According to calculations by Finkelstein[3], this process has a lifetime of 4×10^{-18} sec. and would thus be too fast to