liquid ammonia have now been found in the concentrated solution (16 normal) as well. The times of exposure necessary to observe the ammonia frequencies, $\Delta\nu_3$, $\Delta\nu_4$, and $\Delta\nu_5$ were short enough to avoid difficulty due to the excitation of the water bands, although the latter could not be entirely avoided.

One can hardly decide from the figures given in the table whether or not there is a change in the characteristic frequencies when ammonia is dissolved in water from those observed for the pure substance. It appears that it will always be difficult to make a decision concerning this point because the frequency differences may depend upon the concentration of the scattering substance in the solution and other factors.

Complete details of the experimental work and a critical discussion of the data particularly with regard to changes taking place in solution will be given at a later date.

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April 25, 1931.

Capture of Electrons by Swiftly Moving Alpha-Particles

Capture of electrons by α-particles when the kinetic energy of the electron with respect to the α-particle was equal to that of an energy level of the helium atom were reported by Bergen Davis and A. H. Barnes (Phys. Rev. July 1929) and by A. H. Barnes (Phys. Rev. Feb. 1930).

The results reported depended on observations made by counting scintillations visually. The scintillations produced by α-particles on a zinc sulphide screen are a threshold phenomenon. It is possible that the number of counts may be influenced by external suggestion or autosuggestion to the observer. The possibility that the number of counts of scintillation might be greatly influenced by suggestion had been realized, and a test of their reliability had been made by two methods: (a) The voltage applied to the electrons was altered without the knowledge of the observer (Barnes); (b) the direction of the electron stream with respect to the α-particle path was altered by a small electro-magnet. Such changes in voltage and direction of electron stream were noted at once by the observer. These checks were thought at the time to be entirely adequate.

In examining the data of observation made in our laboratory Dr. Irving Langmuir concluded that the checks applied had not been sufficient, and convinced us that the experiments should be repeated by wholly objective methods. Accordingly we have investigated the matter by means of the Geiger counter. Four additional experimental electron α-ray tubes have been constructed for this purpose.

Capture of the kind reported was often observed over a considerable period of time, but following prolonged observation the effect seemed to disappear. The results deduced from visual observations have not been confirmed. If such capture of electrons does take place, it must depend on unknown critical conditions which we were not able to reproduce at will in the new experimental tubes.

We wish in particular to acknowledge our obligations to Mr. J. R. Dunning who has improved the Geiger counter to such an extent that it is almost an instrument of precision.

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April 25, 1931.

The Results of a Least-Square Adjustment of Cosmic-Ray Observations

Millikan and Cameron have recently published[1] a new series of depth-ionization measurements on the cosmic-rays, from which they conclude that there are four components or "bands" of widely varying intensity and absorption coefficient, the latter probably increasing at first with depth on account of the Compton effect. In a paper read before the Physical Society in December, 1929, the writer showed how least-squared adjustment may be adapted to the analysis of such a combination of rays, provided they obey the assumed absorption law, and provided also that approximate values of the initial intensity and absorption coefficient of each component, such as Millikan and Cameron have estimated, are available. The method uses, as the unknowns

[1] Millikan and Cameron, Phys. Rev. **37,** 235 (1931).

to be adjusted, not the cosmic-ray constants themselves, but the small, unknown corrections to be applied to the approximate values, in order to give the most probable values derivable from the observations. If the above provisions were fulfilled, and if the method were applied to a series of measurements of such precision as those of Millikan and Cameron, the small corrections would certainly appear as a matter of routine calculation.

Through a research grant from the Iowa Academy of Science, the writer has made such an analysis of Millikan and Cameron's latest data. The adjustment was, however, confined to the lower three-fourths of the depth range, in order to avoid the Compton effect as far as possible; and this, incidentally, eliminates the assumed most absorbable fourth component from the calculation. It was found necessary to prepare and use a more extended and more accurate table of the Gold integral than that employed by Millikan and Cameron. The numerical work was performed on a calculating machine by an experienced computer, and carefully checked at every stage. The resulting adjusted values of the corrections were found to satisfy the normal equations exactly, and to give a smaller sum of squared residuals than if the corrections were zero.

It is therefore somewhat disconcerting to have to report that these adjusted values, if applied as corrections, would yield a set of altogether meaningless and physically impossible absorption coefficients and intensities; some of which would even turn out negative.

The writer can arrive at only one interpretation of this, namely, that the assumptions upon which the analysis was made are not justified. Whether the discrepancy arises from insufficiently accurate tentative values of the constants, from the assumption of the wrong number of components, from the persistence of the Compton effect at great depths, or from an altogether erroneous interpretation of the whole phenomenon, it seems necessary to look with serious reserve upon any such sweeping conclusions as to "atom building" as Millikan and Cameron have deduced from the results of their splendid experimental work.

A more detailed account of this investigation will duly appear in the Proceedings of the Iowa Academy of Science for 1931.

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May 1, 1931.

Mutual Impedance of Grounded Wires on the Surface of a Two-Layer Earth

Mr. R. M. Foster's formula[1] for the mutual impedance of any thin grounded wires lying on the surface of the earth has been generalized by us, following his basic assumptions and method of derivation, to cover the case of a horizontally stratified earth having the conductivities λ_1 and λ_2 at depths which are less than or greater than b respectively. We find:

$$Z_{12} = \int\int \left\{ \frac{d^2Q}{dSds} + i\omega \cos \epsilon\, N \right\} dSds$$

with

$$Q = \frac{1}{2\pi\lambda_1} \int_0^\infty \left\{ 1 + \frac{4\alpha_1{}^2(u+\alpha_2)(\lambda_1-\lambda_2)e^{-2b\alpha_1}}{\Delta\left[\alpha_1\lambda_2 + \alpha_2\lambda_1 + (\alpha_1\lambda_2 - \alpha_2\lambda_1)e^{-2b\alpha_1}\right]} \right\} J_0(ru)du$$

$$N = 2\int_0^\infty \frac{u}{\Delta}\left[\alpha_1 + \alpha_2 + (\alpha_1 - \alpha_2)e^{-2b\alpha_1}\right]J_0(ru)du$$

$\omega = 2\pi f =$ radian frequency

$\Delta = (\alpha_1+\alpha_2)(u+\alpha_1) + (\alpha_1-\alpha_2)(u-\alpha_1)\epsilon^{-2b\alpha_1}$

$\alpha_j = (u^2 + i4\pi\omega\lambda_j)^{1/2},\ j = 1$ and 2

$J_0 =$ Bessel function of first kind, zero order.

The integrations are extended in the double integral over the two wires S and s whose elements dS and ds are separated by distance r and include the angle ϵ between their directions. This general formula includes as special cases:

(1) One wire straight and doubly infinite as given by H. P. Evans.[2]

[1] Bulletin of the American Mathematical Society, May 1930, Abstract 289, pp. 367–368.

[2] Evans, Phys. Rev. **36**, 1584 (1930) Eq. (30).