Phys 5

Structure of the Ionosphere

In a recent paper, Appleton and Builder[1] mention a striking fact that on certain occasions, when the ionosphere is being surveyed by the 'pulse' method, there is a reversal in the times of arrival of the two magneto-ionic components into which the upgoing ray is split. They attribute this to differential group retardation, and it occurred to me a short time ago that this effect might throw some further light on a suggestion I have made previously[2], namely, that the whole intermediate space between the E and F layers is ionised to a value very little less than that of the top of the E layer.

I have made some approximate calculations of this group retardation, which indicate that a time delay sufficient to produce the effect noted by Appleton and Builder cannot be produced by a discrete layer 15–20 km. thick without assuming that the density of such a layer can remain constant at a certain value for an appreciable time to a limit of about 1 part in 10,000. If, however, the whole of this intermediate space is ionised, the limit becomes of the order of 10 per cent.

This seems to suggest very strongly that the ionisation of the whole of the intermediate region is comparable with that of the top of the E layer, and I hope to publish the results shortly; but, if this is the case, the group velocity throughout this region will be considerably less than its normal value in free space; and this may affect results derived from observations on the intermediate and F layers. In fact, it raised the question as to whether the 'shelves' have a real existence or merely arise as points of inflexion on a group-velocity curve, and this requires further consideration.

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Aug. 19.

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[1] *Proc. Phys. Soc.*, **45**, 208.
[2] *J. Inst. Elect. Eng.*, **72**, No. 435, March 1933.

Chemical Separation of the Radioactive Element from its Bombarded Isotope in the Fermi Effect

Following the pioneer experiment of Fermi, it has been found by Fermi, Amaldi, D'Agostino, Rasetti and Segrè that many elements up to the atomic number 30, when bombarded by neutrons from a radon-beryllium source, are transmuted into a radioactive element which is chemically different from the bombarded element. In several cases of this type, they succeeded in separating chemically the active substance from the bulk of the bombarded element, and there is no inherent difficulty in getting any desirable concentration of the radioactive element.

They have not observed such chemical changes in elements above the atomic number 30, though many of these heavier elements show strong Fermi effects. For some of these, for example, arsenic, bromine, iodine, iridium and gold, they could show that the activity is carried by the bombarded element, which in the circumstances leads to the conclusion that the radioactive element is an isotope of the bombarded element.

In order to separate the radioactive isotope of the bombarded element from the bulk of the bombarded element, one has to find a new principle of separation. We have attempted to apply the following principle. If we irradiate by a neutron source a chemical compound of the element in which we are interested, we might expect those atoms of the element which are struck by a neutron to be removed from the compound. Whether the atoms freed in this way will interchange with their isotopes bound in the irradiated chemical compound will depend on the nature of the chemical compound with which we have to deal. If we work under conditions in which such an interchange does not take place, we obtain the radioactive isotope 'free', and by separating the 'free' element from the compound we can obtain any desirable concentration of the radioactive isotope.

We have applied this principle to iodine. Ethyl iodide has been irradiated and a trace of free iodine added to protect the radioactive isotope. By reduction and precipitation as silver iodide in water, it was easy to concentrate the activity so as to get from the precipitate ten times as many impulses of the Geiger-Müller β-ray counter as directly from the irradiated ethyl iodide[1]. Apparently a large fraction of the active substance could be extracted from the ethyl iodide. The quantity of the active element obtainable in the precipitate will naturally depend on the quantity of the compound subjected to irradiation.

This principle of isotopic separation has also been applied to some other elements which, like iodine, are transmuted into their own isotopes, and further experiments mostly with organic compounds are in progress.

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Sept. 10.

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[1] *Proc. Roy. Soc.*, A, **146**, 483; 1934.

Activated States in the Spectrum of Copper Hydride

In addition to the well-known band system $^1\Sigma^* \rightarrow {}^1\Sigma$ in copper hydride, we recently reported[1] a new band system $^1\Sigma^{**} \rightarrow {}^1\Sigma$, the activated states $^1\Sigma^*$, $^1\Sigma^{**}$ forming a doublet ($\nu_e^* = 23431$, $\nu_e^{**} = 26369$), previously known in the spectra of gold hydride $\nu_e^* = 27658$, $\nu_e^{**} = 38231$). In the spectrum of silver hydride[3], $^1\Sigma^{**}$ has not been found, although its presence is indicated by irregularities in $^1\Sigma^*$.

Extending our analysis into the ultra-violet region in the spectrum of copper hydride (in emission), we were able to disentangle two new band systems, composed of P-Q-R-branches and forming $^1\Pi \rightarrow {}^1\Sigma$ systems, the constants of the $^1\Pi$-terms being given below:

	ν_0	B_0	γ_0
$^1\Pi^*$	27100	6,39	0,018
$^1\Pi^{**}$	27957	6,065	0,066

($\gamma_0 = \Lambda -$doubling coefficient).

A more detailed account will appear later.

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University of Stockholm.
Aug. 2.

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[1] A. Heimer and T. Heimer, *Z. Phys.*, **84**, 222; 1933.
[2] E. Hulthén and R. V. Zumstein, *Phys. Rev.*, **28**, 13; 1926.
[3] E. Bengtsson-Knave, Dissertation, Stockholm, 1932.

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Letters to the Editor

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Spectrum of Chlorophyll

SOME knowledge about the mechanism of 'assimilation' may probably be gleaned from a detailed picture of the atomic processes involved in the absorption of light in dissolved chlorophyll. As I have not been able to find sufficient *quantitative* data on this subject in the existing literature, I have made some rough measurements to this purpose.

Samples of chlorophyll *a* and *b*, kindly put at my disposal by Prof. Stoll of Basle, were dissolved in alcohol (10 mgm. in 100 c.c.). Absorption measurements were then made with a König-Martens spectrophotometer at different concentrations (10^{-4}–10^{-5}). The results, for which no high precision is claimed, are partly shown in Fig. 1.

As is well known, both chlorophylls show a strong absorption in the red part of the spectrum accompanied by a weaker absorption in the yellow and green part. (To the right of the main peak in Fig. 1 a weaker maximum is to be seen for both chlorophyll *a* and *b*. A closer examination reveals *three* of these maxima for chlorophyll *a* at distances roughly 1, 2 and 3 times 1200 cm.$^{-1}$ from the main peak, and *two* for chlorophyll *b* at distances 1 and 2 times 1400 cm.$^{-1}$. They are probably related to vibrational levels.) The whole of this absorption, extending from about 680 mμ to 500 mμ, will be termed here the 'red band'. In addition, a 'blue band' is present in both cases, beginning at about 500 mμ with chlorophyll *b* and 460 mμ with chlorophyll *a*. Finally one or more 'ultra-violet bands' seem to exist. In the ultra-red one very weak band ($f < 0{\cdot}002$) at 3 μ has been found by D. van Gulik (*Ann. Phys.*, 46, 147; 1915). It does not necessarily belong to the same molecular group as the other bands.

We shall, in the first place, be concerned with the red band. Its 'oscillatory strength' or 'number of absorption electrons per molecule' may be calculated from the integrated absorption as follows:

$$f = \frac{mc^2/\pi e^2}{N}\int d\left(\frac{1}{\lambda}\right)\frac{\log I_0/I}{\log \varepsilon} = \frac{1{\cdot}13 \times 10^{12}}{6{\cdot}06 \times 10^{23} \times 10^{-4}/902}\int d\left(\frac{1}{\lambda}\right)\frac{\log I_0/I}{0{\cdot}434};$$

where N is the number of molecules per c.c., 902 is the molecular weight of chlorophyll *a* (907 for *b*); m, c, π, e and ε ($=2{\cdot}718$) are well-known constants. The result is $f = 0{\cdot}24$ for chlorophyll *a* and $0{\cdot}22$ for chlorophyll *b* ($0{\cdot}13$ and $0{\cdot}11$ respectively for the main peak alone; from F. Perrins' measurements on the polarisation of the fluorescent radiation (*Ann. de Phys.*, 12, 169; 1929) the same value may be deduced: $f = \tau_0/3\tau = 0{\cdot}126$). The values of f for the blue bands were roughly estimated to be about $0{\cdot}3$ or a little more.* These high numbers prove conclusively that the absorption is not due to ionic movement alone but that an *electron* is lifted to a higher level too.

As the *a* and *b* spectra are not essentially different, we shall henceforward refer to them together. The *whole* red band (including its yellow and green tail) but *not* the blue or ultra-violet bands, may be produced in fluorescence by irradiating with light of a sufficiently short wave-length. The main peak alone appears when excited by light of its own wave-length (600–680 mμ produced by filters or prism). By comparison with a mastix emulsion (assumed to scatter without true absorption) it was found that for this red light the yield (fluorescent to incident radiation) is of the order of magnitude 10 per cent; for blue light it was less.

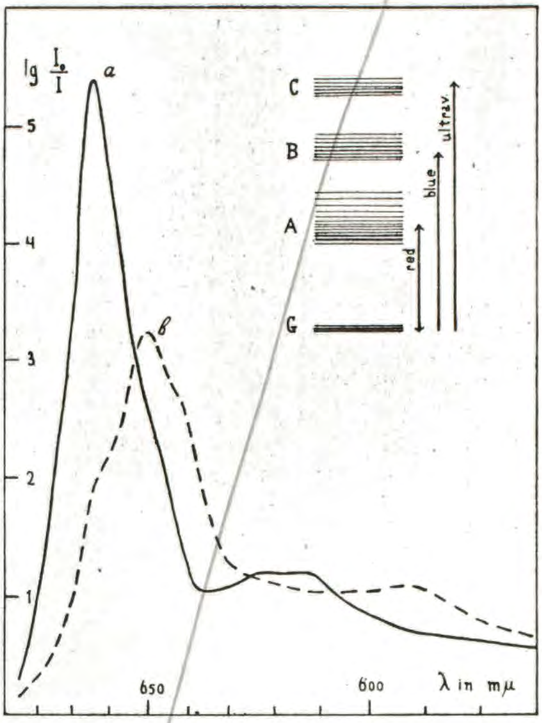

FIG. 1. 'Red' absorption band of chlorophyll *a* (full curve) and *b* (broken curve). Logarithm of incident to transmitted intensity for 1 cm. layer of 1 mgm./10 c.c. alcoholic solution. In the corner: Diagram of energy levels and transitions corresponding to absorption and fluorescence bands.

These facts may be explained by assuming a system of energy levels as indicated diagrammatically in Fig. 1. The electron may jump from its ground state G to at least three different higher levels, A, B and C. These electronic levels are further subdivided by the accompanying ionic vibrations, whilst the different 'rotational levels' are smeared out by the interaction with the surrounding medium. A further essential feature of this picture is the assumption that in state A the electron has only a moderate chance of losing its surplus energy without emitting radiation, for example, by collisions with the surrounding medium, so that there is a reasonable probability (10 per cent) for it to fall back with emission of light. In the higher states the converse is true. To explain this difference we may, for example, suppose that in state A the electron keeps more 'inside' the molecule. An alternative but less plausible explanation would be to ascribe a high probability ($f \gg 0{\cdot}3$) to the transition BA. It would

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* For comparison some rough values I have determined for other substances may be quoted: iodine in carbon disulphide (green band), 0·016; potassium permanganate in water, 0·05; oxyhæmoglobin (double peak between 600 mμ and 500 mμ only), 0·33 (see also R. A. Houstoun, *Proc. Roy. Soc.*, 82, 606; 1909).

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CHEMICAL SEPARATION OF THE RADIOACTIVE ELEMENT FROM ITS BOMBARDED ISOTOPE IN THE FERMI EFFECT

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FOLLOWING the pioneer experiment of Fermi, it has been found by Fermi, Amaldi, D'Agostino, Rasetti and Segrè that many elements up to the atomic number 30, when bombarded by neutrons from a radon-beryllium source, are transmuted into a radioactive element which is chemically different from the bombarded element. In several cases of this type, they succeeded in separating chemically the active substance from the bulk of the bombarded element, and there is no inherent difficulty in getting any desirable concentration of the radioactive element.

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In order to separate the radioactive isotope of the bombarded element from the bulk of the bombarded element, one has to find a new principle of separation. We have attempted to apply the following principle. If we irradiate by a neutron source a chemical compound of the element in which we are interested, we might expect those atoms of the element which are struck by a neutron to be removed from the compound. Whether the atoms freed in this way will interchange with their isotopes bound in the irradiated chemical compound will depend on the nature of the chemical compound with which we have to deal. If we work under conditions in which such an interchange does not take place, we obtain the radioactive isotope 'free', and by separating the 'free' element from the compound we can obtain any desirable concentration of the radioactive isotope.

We have applied this principle to iodine. Ethyl iodide has been irradiated and a trace of free iodine added to protect the radioactive isotope. By reduction and precipitation as silver iodide in water, it was easy to concentrate the activity so as to get from the precipitate ten times as many impulses of the Geiger-Müller β-ray counter as directly from the irradiated ethyl iodide[1]. Apparently a large fraction of the active substance could be extracted from the ethyl iodide. The quantity of the active element obtainable in the precipitate will naturally depend on the quantity of the compound subjected to irradiation.

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