

### Modification of Quanta by Photo-ionisation.

In the course of further experiments on the phenomenon described by Dr. B. B. Ray (NATURE, May 17, p. 746, and June 7, 1930, p. 856), which was explained by Dr. Ray and one of us (NATURE, Sept. 13, 1930, p. 398) as a case of partial absorption of the quantum leading to photo-ionisation, we came across an interesting experimental result. On using the copper  $K_{\alpha_1, \alpha_2}$  radiation and passing it through paraffin 1 mm. thick, we obtained a modified line on the long wave-length side, separated from the parent line by the approximate frequency distance  $\Delta\nu = R$  ( $R =$  Rydberg constant). We are inclined to interpret it as a case of photo-ionisation of hydrogen contained in paraffin in the combined state.

In these experiments, a Uhler and Cooksey type of X-ray spectrometer supplied by Messrs. A. Hilger, Ltd., was used. The crystal of calcite was kept fixed. The photographic plate was firmly clamped in the plate-holder, which is itself a heavy metallic one and is firmly clamped to the body of the spectrograph, leaving no chance of the plate being displaced during an exposure. The modified line was obtained on three plates only when a layer of paraffin was used as an absorber.

The other alternative was to ascribe this line to partial absorption of the quantum by an electron in the aluminium (used as window)  $L_1$ -shell, but this explanation fails, as the energy of ionisation of aluminium in the  $L_1$ -shell is found to be equivalent to about  $5.3R$ , that is, about 72 volts, according to a recent paper by Söderman (*Phil. Mag.*, 616, Sept. 1930).

In a previous letter (NATURE, Sept. 13, 1930), it was pointed out that the phenomenon is analogous to the ejection of electrons from the  $K$ -shell of radioactive atoms by  $\gamma$ -ray quanta coming from the nucleus, as found by L. Meitner, Ellis, and others. But there is one important difference. The  $\gamma$ -ray is supposed to impart the whole of its energy to the  $K$ -electron, which is therefore ejected with the energy  $h(\nu - \nu_k)$ . But in the present case, the X-ray quantum is supposed to impart only a fraction  $h\nu_k$  ( $h\nu_k$  stands for energy of ionisation in the  $K$ -shell) and then continues its journey with the energy  $h(\nu - \nu_k)$ . The two cases are therefore two extremes of the same phenomenon.

It therefore seems probable that the quantum, whether internal (coming from the nucleus) or external (coming from an outside source as an X-ray quantum), may on its passage through atomic shells impart any part of its energy to the electron from  $h\nu_k$  to  $h\nu$ , and be therefore modified from  $\nu$  to the frequency range  $\nu - \nu_k$  to 0. We should expect that the modified beam will appear as a band with a sharp edge at  $\nu - \nu_k$  and extending towards the longer wave-length side indefinitely.

We undertook to verify this deduction by sending the radiation through four layers of black paper (that in which photographic plates are wrapped); we have actually found evidence of this continuous band with a sharp edge at  $\nu - \nu_k$  and extending towards the long wave-length side indefinitely. The copper  $K\beta$  line was used in this case, and the crystal was kept fixed. The range covered by the divergent beam of X-rays was about  $45'$  (equivalent to  $70 X.U.$ ). The crystal was so placed that it could reflect all the wave-lengths between copper- $K\beta_1$  and copper  $K\beta_1 + 70 X.U.$  A single exposure of 50 hours' duration was given. A feeble continuous radiation was indeed recorded in this region, and superposed on this was the modified line with a sharp edge on the short wave-length side and extending towards the long wave-length side as stated in the previous paragraph. The separation between the edge of this line and the parent line was about 20 in  $\nu/R$  units—20.4 being the  $C$  level in  $\nu/R$

units as found by Söderman (*Zeit. f. Phys.*, 52; 1929). A separate exposure was given for 10 minutes to record the copper  $K_{\alpha_1, \alpha_2}$  lines for reference and measurement. No continuous radiation was recorded in the neighbourhood of copper  $K_{\alpha_1, \alpha_2}$ , as the former is too feeble to be photographed in an exposure of 10 minutes.

These experiments seem therefore to prove that the phenomenon is general, and the quantum can impart to the bound electron energy varying from  $h\nu$  to  $h\nu_k$ , and be modified to any frequency less than  $\nu - \nu_k$ . Further experiments are proceeding.

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### Simple Deposition of Reactive Metals on Noble Metals.

ACCORDING to Nernst's theory of electrode potentials, a very small concentration of a reactive metal should be deposited on a noble metal when the ions of the former are brought in contact with the latter. The effect is usually regarded as being too small for demonstration. Dr. G. von Hevesy showed the effect by radioactive methods some years ago. He deposited radioactive isotopes of lead and bismuth, presumably as metal, on such noble metals as platinum, gold, mercury, and copper, in some cases quantitatively; he showed, indeed, that the ions of any radioelement could to some extent be deposited on noble metals when the latter were merely immersed in a solution. The effect, I find, can be shown by some metals which are not radioactive. I have obtained it with reactive metals like uranium, titanium, tungsten, and molybdenum on such noble metals as mercury, copper, and tin.

It is obtained simply. A liquid amalgam is shaken vigorously with a solution of a uranium, titanium, tungsten, or molybdenum compound in acid for a few minutes or less, removed from the solution, and well washed. To the amalgam 0.1 gram of pure zinc is added, and the minimum concentration of sulphuric acid at which hydrogen is found to be evolved determined. Whereas with an amalgam employed as a blank no hydrogen is visible with  $2N$ -sulphuric acid, the amalgams which have been shaken with uranium, titanium, tungsten, and molybdenum solutions are found to evolve hydrogen down to concentrations of 0.012, 0.0025, 0.002, and 0.002  $N$ -sulphuric acid respectively. This catalytic effect cannot be due to the mere act of shaking, since it is not given when acidified solutions of manganese, chromium, and vanadium, which are metals similar to those given above, are shaken with amalgams to which zinc is afterwards added. Nor can it be ascribed to oxides or other compounds of these metals, since these have never been shown to catalyse the formation of hydrogen when zinc is brought in contact with a dilute acid. In the well-known experiment of adding copper sulphate or platinic sulphate to zinc immersed in acid in order to catalyse the evolution of hydrogen, it is difficult to think that the catalyst is not metallic copper or platinum. These catalysts, uranium, titanium, tungsten, and molybdenum, behave as though they were deposited platinum, and are therefore presumably in the metallic state.

This view is supported by the fact that any of these metals when deposited by a current on a mercury cathode behaves catalytically towards the evolution of hydrogen exactly as does the amalgam which has been shaken with a solution. Such amalgams appear entirely metallic. Uranium and titanium have