

For $Z \sim 20$ the components ψ_1, ψ_2 of the K -electron are small compared with the components ψ_3, ψ_4 . Similarly, ψ_P has two large and two small components differing by a factor of the order of $1/10$. We may suppose \mathbf{A}'' to be an operator combining the two small components of ψ_P with the two large components of ψ_e^* . This arrangement gives a factor $1/100$ in the terms containing the small proton components, and a factor $1/200$ in the terms containing the small electron components. Thus, by addition, F_k/F will contain a factor $3/200$ from this combination; that is, for $Z = 21.0$, we may take F_k to be 0.003 for $\alpha = 2$, and 0.035 for $\alpha = 4$. The positron emission will now be given by

$$F = A \int_1^{W_0} W_0 (W + 1) (W^2 - 1)^{1/2} (W_0 - W)^{\alpha} dW \quad (c) \quad \begin{matrix} \alpha=2 \text{ Fermi} \\ \alpha=4 \text{ Konopinski-Uhlenbeck} \end{matrix}$$

F will again depend sensitively upon the value of W_0 , but we can take as suitable values 1.5 for $\alpha = 2$ and 0.75 for $\alpha = 4$. This gives for F_k/F approximately the values $1/500$, $\alpha = 2$, and $1/25$, $\alpha = 4$. It is possible that K -electron capture for the ratio $1/25$ has escaped detection, although its existence should be revealed by further experiments. The interesting point arises that, if the $\alpha = 4$ interaction is assumed, we obtain a definite prediction of the low-energy end of the positron spectrum, which is given by the integrand of (c). This leads us to expect a large number of slow positrons. It is important to note that this latter conclusion seems to hold only for allowed transitions. For forbidden transitions (c) has a more complicated form.

In the Fermi theory, F_k/F is about $1/3$ or $1/500$ according as one adopts the law (a) or (b). The actual interaction law may also be a linear combination of (a) and (b), and it is easy to calculate the proportion necessary to give any intermediate ratio. It should be noted that, as this ratio decreases from $1/3$, we require a rapid increase in the percentage of (b); for example, when the ratio has decreased to $1/30$ we already need more than 90 per cent of the interaction (b).

We see that if we accept the experimental evidence that the probability of absorption of a K -electron relative to that of positron emission is less than the value required by the Konopinski-Uhlenbeck theory, then the theory must be replaced by a modified form which gives many more slow positrons and fewer slow electrons. This appears to be in reasonable agreement with the direct observation of the spectrum.

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¹ Møller, *Phys. Rev.*, **51**, 84 (1937); *Phys. Z. d. Sowjetunion*, **11**, 9 (1937).

² Jacobsen, *NATURE*, **139**, 879 (May 22, 1937).

³ Hoyle, *Proc. Camb. Phil. Soc.*, **33**, 286 (1937).

⁴ Fermi, *Z. Phys.*, **88**, 171 (1934).

⁵ Darwin, *Proc. Roy. Soc., A*, **118**, 674 (1928).

⁶ Mercier, *NATURE*, **139**, 797 (May 8, 1937).

the microphotometer curves of the resultant pattern reveal clearly four distinct components of $H\alpha$ with intensities and positions roughly as given by theory. There are no ghosts in the Lummer plates and the interference of lines of the secondary spectrum of hydrogen has been eliminated.

We are now engaged in obtaining quantitatively the intensity and position of these components.

We feel that this method (new, so far as we know) may be of service in the study of the fine and hyper-fine structure of the spectrum lines of other elements.

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¹ *Phys. Rev.*, **30**, 266 (1927).

Raman Spectra of Oxonium Compounds

M. WOLKENSTEIN and G. K. Syrkin have published in a recent communication in *NATURE*¹ the Raman spectrum of equimolecular mixtures of ether and hydrogen chloride in the liquid state¹. In 1935 we studied² the Raman spectrum of the system ethyl ether plus hydrogen bromide at low temperatures (228°K .) and announced there further work on this subject. The publication of these results was delayed owing to unforeseen circumstances.

We investigated solutions of the compounds $\text{CH}_3\text{OH} + \text{HCl}$ (HBr), $\text{C}_2\text{H}_5\text{OH} + \text{HCl}$ (HBr), $(\text{CH}_3)_2\text{O} + \text{HCl}$ (HBr) and $(\text{CH}_3)_2\text{CO} + \text{HCl}$ (HBr) in excess of hydrogen halides. The compounds were prepared, dissolved in excess liquid hydrogen halide and the resulting solution filled into the Raman tube, all in one operation, in a high vacuum apparatus at low temperatures, thus eliminating all possibilities of chemical reaction (formation of R. Hal.). Under these conditions, we obtained spectra of the solutions, which were characteristically different from the spectra of the components. We obtained the following frequencies:

$\text{CH}_3\text{OH} \dots \text{HCl}$ ($t = -75^\circ \text{C}$., molecular ratio = $1:1.8$). 465(2), 645(3), 991(4), 1083(5), 1181(1), 1357(3), 1449(5), 2956(10), 3019(7), 3664(3).

$\text{CH}_3\text{OH} \dots \text{HBr}$ ($t = -62^\circ \text{C}$., mol. ratio = $c. 1:5$). 391(3), 497(4), 629(4), 887(2), 984(3), 1066(3), 1449(3b), 2907(4), 2970(10), 3047(5).

$\text{C}_2\text{H}_5\text{OH} \dots \text{HCl}$ ($t = -75^\circ \text{C}$., mol. ratio = $1:2.1$). 398(3), 507(2), 613(2), 646(2), 873(3), 1021(3), 1094(2), 1281(2), 1343(3), 1450(6), 2928(8), 2977(10), 3357(1).

$\text{C}_2\text{H}_5\text{OH} \dots \text{HBr}$ ($t = -65^\circ \text{C}$., mol. ratio = $c. 1:5$). 431(2), 520(4), 597(4), 708(2), 829(5b), 925(1), 1048(2), 1296(1), 1377(2), 1450(6), 2940(8), 2984(10).

$(\text{CH}_3)_2\text{O} \dots \text{HCl}$ ($t = -80^\circ \text{C}$., mol. ratio = $1:2.5$). 356(1), 432(3), 506(3), 890(7sb), 947(1), 1006(1), 1063(3), 1444(8b), 2828(6), 2928(10), 3002(9).

$(\text{CH}_3)_2\text{O} \dots \text{HBr}$ ($t = -32^\circ \text{C}$., mol. ratio = $1:1.7$). 268, 395(6), 506(2), 824(7b), 896(2), 965(1), 1023(1), 1440(8b), 2834(4b), 2948(10b), 3037(9b).

$(\text{C}_2\text{H}_5)_2\text{O} \dots \text{HCl}$ ($t = -80^\circ \text{C}$., mol. ratio = $1:3.5$). 327(1), 418(2), 491(3), 767(2), 823(2b), 955(2), 997(3), [1058(1)], 1270(3), 1450(7), 2878(1), 2942(10), 2981(10).

$(\text{C}_2\text{H}_5)_2\text{O} \dots \text{HBr}$ ($t = -43^\circ \text{C}$., mol. ratio = $1:2.5$). 303(1), 406(5), 470(1), 678(1sb), 830(0), 920(0), 996(4b), 1071(1), 1137(0), 1263(1), 1459(6b), 2866(0), 2940(10), 2984(10).

The detailed discussion of the spectra led to the conclusion that the compounds do not exist in solution of excess hydrogen halide as 'oxonium' compounds $(\overset{\text{R}}{\text{R}}\text{O}^+\text{H}) + \text{X}^-$, but as compounds with tetravalent oxygen. We propose calling this type of compound an 'oxan' compound.

Structure of $H\alpha$ of Hydrogen

THE structure of the lines of the Balmer spectrum of hydrogen was investigated in this laboratory some years ago. Recently we have attacked the problem again, using two Lummer plates, not crossed as in the investigations of Kent, Taylor and Pearson¹, but dispersing in the same plane. With this arrangement,