Proceeding upwards from the maximum extent of the lesion retrograde degeneration could be followed for a short distance in the radix spinalis of nerve V, the substantia gelatinosa, the tractus rubro-spinalis and the tractus DEITERS descendens but all these structures were normal at the caudal level of the inferior olives. Primary degeneration of the lesion itself could be followed upwards as a shallow, but fairly wide, line of cleavage between the fasciculus BURDACH and the radix spinalis of nerve V. There was also secondary degeneration of the lateral and ventral two-thirds of the fasciculus BURDACH but not of the nuclei GOLL and BURDACH, the fibrae arcuatae internae nor the medial lemniscus. Secondary degeneration could be followed likewise in the medial part of the area ovalis corporis restiforme and in the fibres terminating in the nucleus corporis restiforme, the cells of which were normal. The degeneration in the tractus spino-cerebellaris ventralis was followed upwards to a level between the nucleus of nerve VII and the superior olives.

The physiological observations and conclusions reported here are those of the senior author while the anatomical studies and conclusions are those of the junior author. These new experiments seem to have verified the conclusions of the previous publication referred to and to have adduced further physiological evidence to the effect that, in rabbits, the nuclei of GOLL and BURDACH on one side exert an influence over the "body righting reflex acting on the body" of the opposite side. The anatomical examination showed that in the first two cases described, among other structures, the nuclei of GOLL and BURDACH were destroyed on the left side and ascending degeneration could be followed in the right medial lemniscus. Consequently the anatomical study has not explained the physiological differences noted between these, beyond the fact that the lesion in the second case was smaller and more caudal than that in the first. In the third case the disappearance of the reflex on the homolateral side cannot be ascribed to a centripetal effect alone, as many pathways in the lateral column of the spinal cord, both centripetal and centrifugal, were destroyed.

Physics. — *On the influence of electric fields on the absorption spectrum of potassium* [1]. By C. J. BAKKER. (Communicated by Prof. P. ZEEMAN).

(Communicated at the meeting of May 27, 1933).

1. *Introduction.* The method of the investigation of the absorption has been applied by various authors, with great accuracy, to the investigation of the inverse quadratic STARK-effect, especially of the alkalis.

[1]) Cf. the paper by SEGRÈ and WICK in this same number of the Proceedings. It ought to have been inserted after the present communication.

As it is well known the principle of the absorption method is, that the metallic alkali is vaporised in an absorption tube; the pressure must be chosen in such a way, that it is high enough to guarantee a sufficient absorption, but on the other hand so low, that it is possible to establish high electric fields between two parallel plates, being at a small distance in the absorption tube.

In his investigation on the inverse quadratic STARK-effect of the *Na-D* lines LADENBURG[1]) made use of a thickness of 28 m.m. of the sodium vapour layer and a vapour pressure of about 10^{-5} m.m. In this way fields of 160.000 V/c.m. could be reached. The quadratic STARK-effect demonstrates itself in a very small shifting of the lines to the red, and was observed in fields stronger than 100.000 V/c.m. The largest displacement was 0.025 Å in a field of 160.000 V/c.m.

GROTRIAN and RAMSAUER[2]) investigated the inverse quadratic STARK effect of the 2^{nd} and 3^{rd} member of the principal series of potassium, while GROTRIAN[3]) investigated the 2^{nd} and 3^{rd} member of the principal series of sodium. As length of absorbing layer 80 c.m. was chosen; the vapour pressure of the alkali metal could remain low (for potassium about 7×10^{-3} m.m.), so that electric fields of 100.000 V/c.m. could be established. In the case of potassium the observed displacements were smal displacements to the red, in the case of sodium to the violet.

YAO[4]) has extended the observations to the second members of the principal series of *Rb* and *Cs*. Here also the observed shiftings to the red showed quadratic dependence on the field strength.

The investigations mentioned are all restricted to the lower principal series members of the alkali metals.

As far as the present author is aware, KUHN[1]) is the only one who, by means of the absorption method, has investigated the influence of electric fields on the higher series members, lying in the neighbourhood of the series limit. Potassium was the alkali metal he made use of. The condenser plates had a length of 35 c.m. In order to guarantee sufficient absorption the vapour pressure had to be raised so high, that only fields not stronger than 300 V/c.m. could be reached. This field strength however proved already sufficient to demonstrate, that the place where the absorption series ends displaces itself with increasing electric field strengths to higher wave lengths. Moreover new absorption lines appear about in the middle between the principal series lines and according to KUHN only in the light, polarized perpendicularly to the direction of the electric field (σ-polarization). These new lines are doubtless so called "forbidden" lines, which appear under the influence of the electric field. As the present author

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1) R. LADENBURG, Phys. Zs. **22**, 549, 1921; Zs. f. Phys. **28**, 51, 1924.
2) W. GROTRIAN and G. RAMSAUER, Phys. Zs. **28**, 846, 1927.
3) W. GROTRIAN, Zs. f. Phys. **49**, 541, 1928.
4) Y. T. YAO, Zs. f. Phys. **77**, 307, 1932.
5) H. KUHN, Zs. f. Phys. **61**, 805, 1930.

feels interested in the behaviour of "forbidden" lines and some difficulties arose in connection with the interpretation of the results mentioned the experiment was repeated. It will appear that in some respect the results obtained deviate from those of KUHN.

2. *Experimental part.* The absorption tube used (Fig. 1) was a 1 m. steel bicycle tube with an inner diameter of 30 cm. The ends of the tube were closed by thin windows of fused quartz, attached with sealing wax

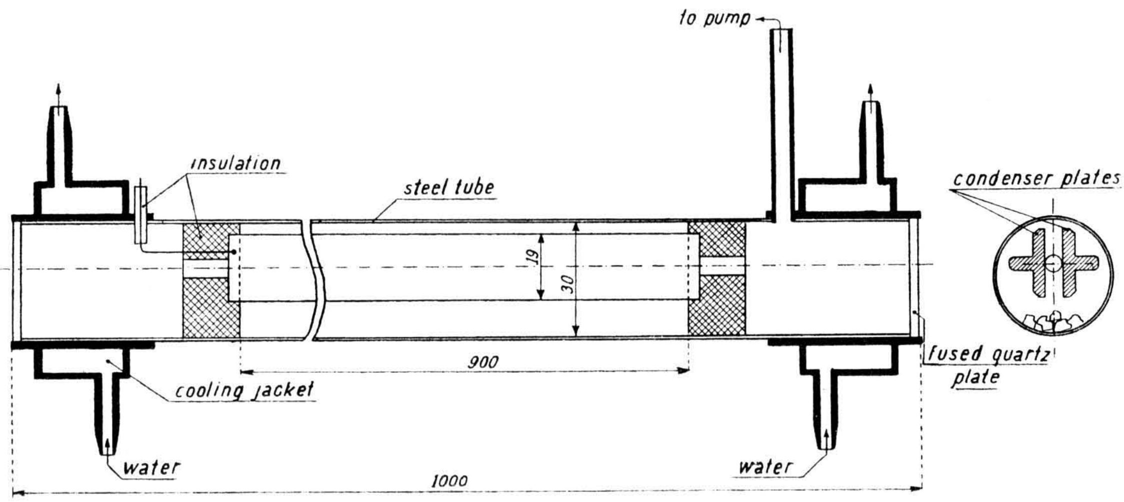


Fig. 1. Scheme of the absorption tube.

and kept cool by the circulation of cold water through two jackets, fitted on the ends of the tube. *Ni*-Chromium heating wire, insulated from the tube with asbestos plate, was wound along a distance of 50 cm. The temperature, in order to get a sufficient vapour pressure, had to be 530°, with which, according to the LANDOLT—BÖRNSTEIN tabels a potassium vapour pressure of 4.5 cm. corresponds. It is, however, not to be expected that the pressure is constant over the total length of the heating coil, as the potassium distils from the middle of the tube towards the places, where the heating coil ends. The condenser plates were 90 cm. steel plates of T-form, fitted with their planes vertically in the tube, a little above the centre, in order to leave room for the potassium metal at the bottom. The ends of the plates were screwed in insulating disks of eternite. As these disks were at a great distance in the cool part of the tube no potassium could condense on them during the heating and the insulation was maintained. The disks could slide in the tube so that the plates could expand freely during the heating. Moreover the T-form makes the plates so strong, that the electrostatic forces were certainly not sufficient to cause them to bend. In this way the field strength remained constant during the heating. The distance of the plates was 5 mm. One of them was connected with the tube and earthed ; a copper wire, passing through the side of the tube and insulated from it, led to the other place.

The high tension was supplied by a little EVERSHED generator, which is able to give only small currents. In the experiment the resistance between the condenser plates, mainly fixed by the potassium vapour pressure, was about 10^5 Ω. The electric current was continually controlled during the exposures by means of a milliam.meter, protected by a silite resistance of 500 Ω. The electric tension between the plates was measured with a HARTMANN and BRAUN electrostatic voltmeter, of the multi cellular type. The maximum field strength attained was 1600 V/cm. In case of higher field strengths discharges in the tube took place and the field could not be maintained.

The potassium was put in the tube in bar form and melted in vacuum. After that the tube was filled with hydrogen or nitrogen of 10 cm. pressure in order to avoid too quick a distillation of the potassium.

As continual light source a water cooled hydrogen tube due to CHALONGE [1]) was used, which is operating continually at 300 milliamp.

The greater part of the photographs was made with a HILGER *E* 2 quartz spectrograph. Experiments with a HILGER *E* 1 could not be quite finished. The exposure time ranged from 10 minutes for the *E* 2 to 30 minutes for the *E* 1.

A calcite plate was placed in the light beam before the slit of the spectrograph, so that the polarizations parallel to the electric field (π-polarization) and perpendicular to it (σ-polarization) could be photographed simultaneously and separately.

In general exposures with different field strenghts were directly made one after an other. To control the vapour pressure in the tube such a series of exposures was always begun and finished with a fieldless exposure.

Photograms were made by means of a Zeiss (photo-electric) photometer.

3. *Results.* The results will be given along with the photograms.

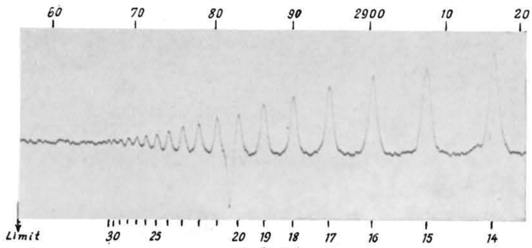
Photogram 1 shows the principal series of potassium in absorption, taken fieldless. As it is well known the principal series consists of the members $4S$—nP $n=4, 5, 6 \ldots\ldots$ [2]). The photogram starts at the long wave length side with the member $4S$—$14P$ [3]), while the series can clearly be followed until the member $4S$—$31P$ at the short wave length side. For observation of still higher series members the dispersion is too small and the grain of the plate is disturbing. The emission line lying between the members $4S$—$20P$ and $4S$—$21P$ is the *Si*-line $\lambda=2882$ from the light source.

1) D. CHALONGE and M. LAMBREY, Rev. d. Opt. **8**, 232, 1929.

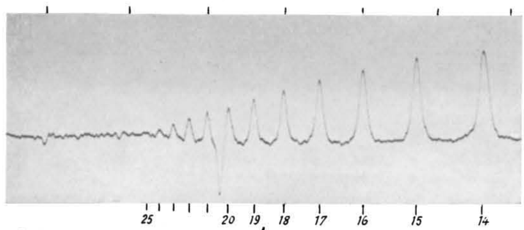
2) Accurate wave lengths measures of the principal series of potassium are to be found n a paper bij S. DATTA, Proc. R. Soc. London A **101**, 539, 1922.

3) The beginning of the series has been left out in the photograms, as it is of no interest here.

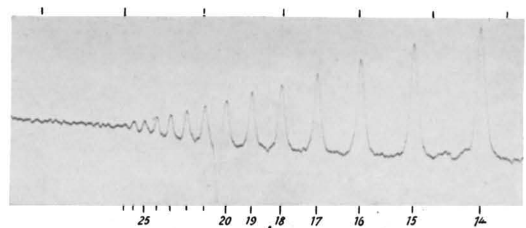
C. J. BAKKER: On the influence of electric fields on the absorption spectrum of potassium.



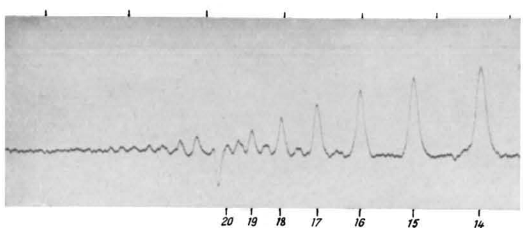
1. *no field*



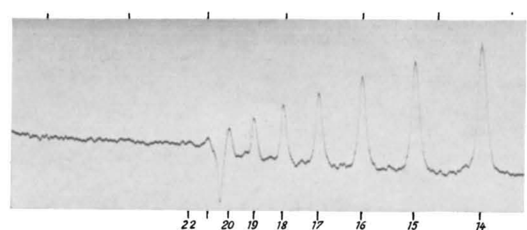
2 A. *200 V/cm* π



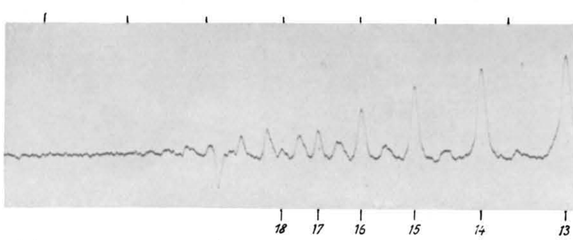
2 B. *200 V/cm* σ



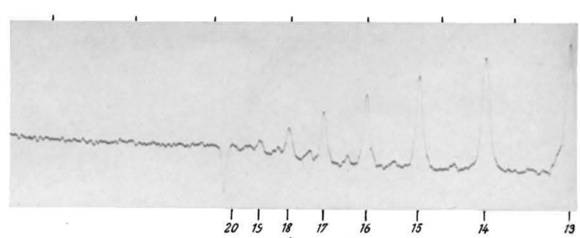
3 A. *780 V/cm* π



3 B. *780 V/cm* σ



4 A. *1600 V/cm* π



4 B. *1600 V/cm* σ

The photograms 2*A* and 2*B* are taken from photographs in π and σ polarization. The electric field in the tube was 200 V/cm. It can clearly be seen that the place where the principal series breaks down has been moved to longer wave length under the influence of the electric field [1]). In π-polarization the series is observed till the member $4S$—$25P$ and in σ-polarization till the member $4S$—$27P$. A simple qualitative explanation of the shifting of the series limit can easily be given: Suppose that a highly excited electron approximately has a potential energy $-\frac{e^2}{r}$ in the field of the atomic core. By an electric field of strength F in the z-direction the potential energy in this direction changes with $-eFz$ and a potential barrier appears. Fig. 3 shows this. Above this barrier the eigen values are continuous, so that the series breaks down at a distance $\triangle\nu = 2e\sqrt{eF}$ cm.$^{-1}$ from the normal series limit. It appears that this value

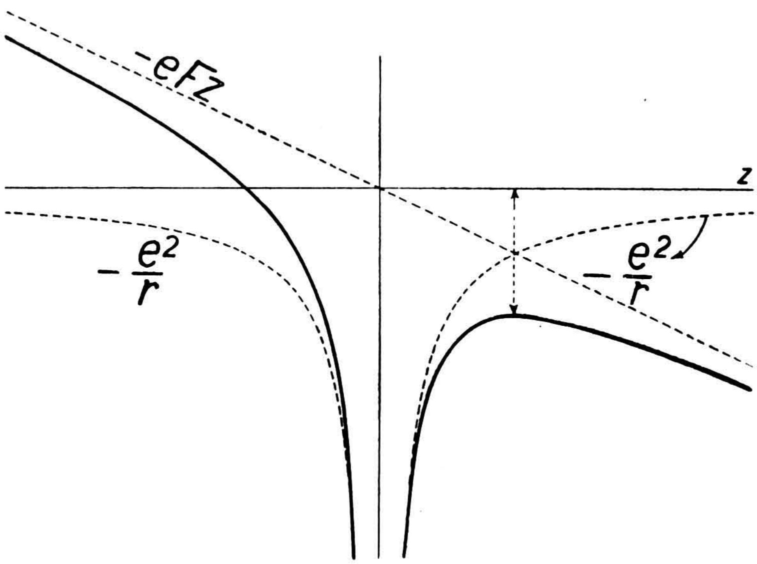


Fig. 3.

does not agree quantitatively with the experimental results, to a degree that the observed distance $\triangle\nu$ is always larger.

It was thought that this could be explained by the effect of forced ionization — transparency of the potential barrier — occurring especially when the electron is highly excited. KUHN, however, has already shown that this effect has only a slight influence, in case of the low fields used.

There is another point, introduced by SEGRÈ and WICK [2]), which appears

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[1]) This effect corresponds with that wich H. RAUSCH VON TRAUBENBERG, R. GEBAUER and G. LEWIN, Nat. w. **18**, 417, 1930, investigated in their experiments on the behaviour of the BALMER series in very strong electric fields and which has been treated theoretically by C. LANCZOS, Zs. f. Phys. **68**, 204, 1931.

[2]) E. SEGRÈ and G. C. WICK, Proc. R. Soc. Amsterdam, 534, 1933. In a discussion with the present author Dr A. J. RUTGERS suggested a similar explanation.

to be much more essential here and far more important, than the effect of forced ionization. This point is the existence of a sum rule, according to which the intensity of the permitted principal series lines is transferred to the „forbidden" lines, of which we come to speak.

The photograms 3*A* and 3*B* are from photographs in π and σ-polarization, taken with a field of 780 V/cm. in the absorption tube. The place where the principal series breaks down is clearly moved further to the long wave length side than in 2*A* and 2*B*, as we may expect; the series in π-polarization is observed till the member $4S$—$20P$ and in σ-polarization till the member $4S$—$22P$. *New* lines appear especially clearly in π-polarization reaching farther to the violet than the principal series members and lying between those members. They start weakly between the members $4S$—$16P$ and $4S$—$17P$, increase in intensity to a maximum about the place where the principal series breaks down and then decrease in intensity to fade away. No doubt those new lines are "forbidden" lines appearing under the influence of the electric field. The situation of the lines is in accordance herewith as the high S und D terms are lying about in the middle between the P-terms. According to quantum mechanic perturbation calculations the eigen functions of the high S and D terms are "mixed" with those of the neighbouring P terms; as the latter combine with the lowest term $4S$ a transition probability of the S and D terms (disturbed) to the $4S$ appears. As the orbit impulse is zéro for a S term and cannot change its value, transitions $4S$—nS can only appear in π-polarization. $4S$—nD transitions can appear, though weaker than the analogous $4S$—nS transitions, in π and σ-polarization. There is a slight indication of new lines in 3*B* (σ-polarization), being $4S$—nD transitions, but these are much more prominent in 4*B*.

The photograms 4*A* and 4*B* are from photographs in π and σ-polarization, taken with a field of 1600 V/cm. in the absorption tube. The principal series is driven back much more and ends in π-polarization with the member $4S$—$18P$ and in σ-polarization with the member $4S$—$20P$. The forbidden lines are very conspicuous in π-polarization, but they are also clearly observed in σ-polarization.

4. *Summary.* A description is given of an experiment on the influence of electric fields on the absorption spectrum of potassium. It is shown that with increasing fieldstrength the place where the absorption series ends, moves to longer wave lengths. Under the influence of the electric field new absorption lines appear, which are to be interpreted as "forbidden" lines. A qualitative explanation of the results has been given.

In conclusion the author wishes to express his best thanks to Prof. P. ZEEMAN for valuable advice and suggestions.

Laboratory "PHYSICA" of the University.

Amsterdam, May 1933.