Physics. — *The Boltzmann distribution in the Hydrogen arc.* By L. S. ORNSTEIN, Miss J. G. EYMERS and J. WOUDA. (Communication from the Physical Laboratory of the University of Utrecht).

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LANGMUIR [1]) has described a method of forming atomic Hydrogen which in recombining furnishes the energy necessary to melt metals of high melting point. The arc constructed in his way shows a very interesting spectrum, which has been studied in our Institute.

The arc is drawn between two Tungsten rods, surrounded by tubes through which Hydrogen flows. The arc is surrounded by this gas, which is dissociated by the high temperature.

The arc emits the Balmerlines very strongly, the secondary spectrum of Hydrogen however is absent. The arc consists of a flame with a kernel which emits the Balmerlines; the intensities of these lines have been measured.

An image of the kernel enlarged 5 times is formed on the slit of a *E* 2 Hilger quarz spectrograph. Exactly before the slit a small screen was placed on which the exact place of the slit was marked. The screen could be removed by an electric current. In this way it was possible to adjust the arc and to take very short times for the exposure.

The spectrogram of the arc shows very much ultraviolet light, the Balmerlines are not at all blended by Tungsten lines and sufficiently free from continuous background, the lines H_α and H_β are quite free as a photogram taken with the Moll recording photometer shows (fig. 1)

In order to get the satisfactory spectra obtained it was necessary to choose adaequate conditions. From provisory experiments it became clear that the Balmerspectrum was formed under good conditions if for given electric current the flow of Hydrogen was regulated in such a way that the arc was on the point to be blown out. When the distance of the electrodes is increased the flow ought to be diminished since the arc is than more easely blown out. Therefore the distance of the electrodes was taken as small as possible (between 1 and $1^1/_2$ mm.), a distance at which the continuous spectrum of the electrodes did not yet give any trouble. The density marks on the plate were taken with a tungsten

[1]) Conf. Bonhöfer Ergebnisse d. exacten Naturw. Bd. **6**, p. 209 1927.

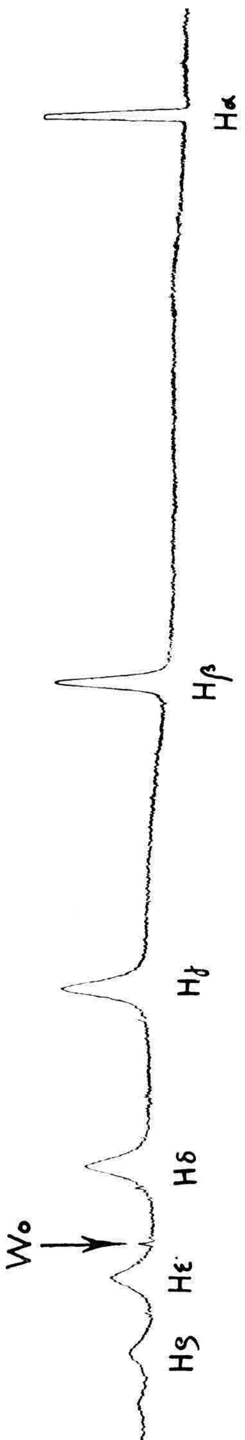

Fig. 1.

band lamp standardized energetically. The Balmerlines are strongly broadened- as a comparison with the tungsten lines shows, the cause is the Starkeffect from the ions in the arc. The Starkeffect strongly diminishes the self reversal of the Balmerlines.

The intensity of the broad lines cannot be found from the maximum intensity but the intensity-wave length dependence ought to be determined for each line and the surface of this curve gives a measure for the intensity. The broadening of the lines is shown by fig. 2, where the distance $d\lambda$ from the maximum of intensity has been plot against the intensity for H_α.

At low Hydrogen pressure strong tungsten lines appeared. The Voltage at the arc amounts 80 V. at 4 Amp. and 60 V. at 8 Amp.

A provisory experiment shows that the same phenomena appear also when carbon rods are taken instead of the tungsten poles.

Results.

The investigations performed in this Institute on arcs have shown that BOLTZMANN distribution of energetic levels with a very high temperature exists. Now the same question can be discussed for Hydrogen in the arc described above. The spectrum of atomic Hydrogen is specially important in this respect as for this case quantum mechanics furnishes theoretical values for the transition probabilities. The intensity of a Balmerline emitted by an element of the arc containing N atoms can be described by the formula:

$$N\,Ag\,e^{-\varepsilon/kT}$$

where Ag is the product of the emission probability (corrected by ν^4 for the intensity), ε the energy of the level, k the BOLTZMANN constant and T the temperature.

When we plot $\frac{I}{Ag}$ in logarithmic scale against the energy we find points on a straight line if the BOLTZMANN distribution is true. From the slope if this line the temperature can be determined. The experiment has been

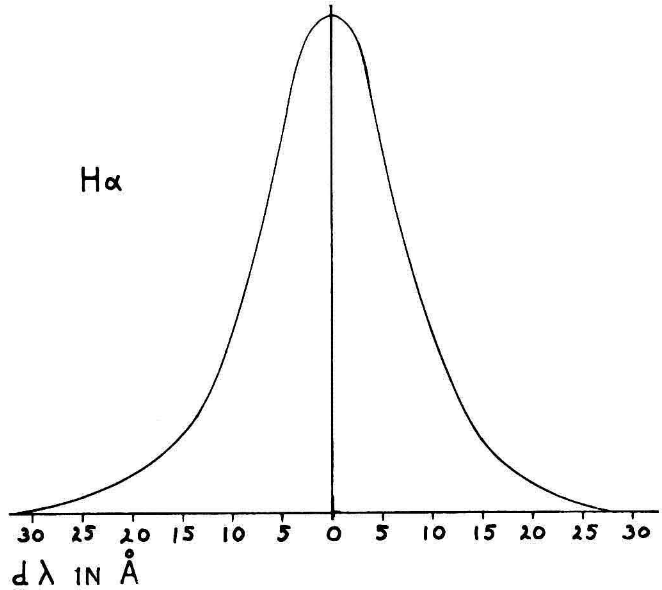

Fig. 2.

carried out for three arcs and a straight line was found. The results are given in a table.

Tension	Current	*Wo* lines	Temperature
80 V.	4 Amp.	Few	4900° K.
60 V.	8 „	Few	5300° K.
— V.	8.5 „	Many	6300° K.

The *Wo* lines were absent in the arc of the lower temperature; when the current is constant, the pressure of the Hydrogen diminished, the *Wo* lines appear. This is in accordance with an investigation published by L. S. ORNSTEIN and H. BRINKMAN in *Naturwissenschaften*. If the mechanism of the arc is governed by the dissocation as in the theory of SAHA many particularities of the spectrum of an arc can be understood. For example in the high temperature Hydrogen arc the ionisation of *Wo* is possible which cannot yet occur at the lower temperature.

As a following confirmation of the high temperature existing in the arc we mention provisory experiments with monochromator, thermopile and relais galvanometer. In the region of H_α and H_β there is no continuous back ground; however in the infrared of about 2μ a strong emission is present. The gas (H_2O) in the arc has strong absorption in this region, therefore it will emit a black body radiation for the region of the broadened bands for which it is opaque. Also this point will be investigated in the future.

Utrecht, April 1931.