[3] F. C. Hoyt, *Physic Rev.*, **26,** 749 (1925).
[4] See M. Born, "Vorlesungen über Atommechanik," Berlin, 1925, p. 184.
[5] W. Heisenberg, *Zeit. Physik,* **33,** 879 (1925).
[6] M. Born and P. Jordan, *Ibid.*, **35,** 858 (1925).

ABSORPTION AND RESONANCE RADIATION IN EXCITED HELIUM AND THE STRUCTURE OF THE 3889 LINE

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In a recent issue of *Nature*[1] a brief letter was published on the results of some experiments on the optical properties of excited helium. A detailed account of the experimental work and plates representing the results obtained are being sent to the *Philosophical Magazine* for publication. The following is a summary of those results, with the addition of some discussion of their significance.

The method used differed from the usual photometric method in that the light, after passing through the absorbing column, was resolved by means of an echelon grating and examined for a weakening of the central portion of the line, which would be affected by the absorption. It was found possible to completely reverse several lines of the helium spectrum by an absorbing column 80 cm. in length. The lines reversed included not only the principal series of both the singlet and doublet systems, but also the diffuse subordinate series of both systems, not, however, the lines of the sharp subordinate series. Table 1 gives a list of the lines which were reversed.

TABLE 1

Helium Lines Reversed by Absorption in a Column of Excited Helium of Length 80 Cm. Pressure of Gas 4.0 Mm.

WAVE-LENGTH	LINE	WAVE-LENGTH	LINE
3889 Å	1σ–2π	5016 Å	$1S$–$2P$
3187	1σ–3π	3964	$1S$–$3P$
5876	1π–2δ	3614	$1S$–$4P$
4471	1π–3δ	6678	$1P$–$2D$
4026	1π–4δ	4922	$1P$–$3D$
3819	1π–5δ		

In agreement with the results of other observers, it was found that the presence of small amounts of hydrogen in the discharge greatly reduced the absorption. This is probably due to a decrease in the life of the excited atoms produced by the presence of the hydrogen.

At high pressures the doublet system lines were more strongly absorbed than were the singlet system lines, while at low pressures the reverse was found to be the case. This is in agreement with the variation of the relative intensity of the two systems with pressure in the emission spectrum of helium. The doublets are relatively intense at high pressure and the singlet lines at low pressure. This shows definitely that the excitation of helium by electron impacts is predominantly to the 1σ state at higher pressures while low pressures the excitation to the $1S$ state is more important.

For a given series the absorption was found to fall off rapidly as the higher terms of the series were considered. In the case of the 1σ–$m\pi$ series only the first three terms have been studied and all show strong absorption. In the case of the 1π–$m\delta$ series absorption could be detected only to the fourth term. With the $1S$–mP series absorption was found to the fourth term and in the case of the $1P$–mD series only to the second term, and then only with strong excitation in the absorbing column.

Discussion.—In considering the emission spectrum of a gas, the decrease of intensity of the lines of the series as the higher terms are considered, may be due to two causes; (*a*) the number of atoms in the states of higher energy which may move to a state of lower energy with the emission of radiation. Then as the higher terms are considered the decrease of intensity may be attributed to a decrease in the number of atoms in the states of high energy.

(*b*) The probability of the transition considered occurring. In dealing with the absorption of a given series, only (*b*) can influence the results as all the lines of a given series are due to transitions of atoms from the same initial state. Thus the falling off of the absorption with the higher terms of the series, must be due to a decrease in the probability of a transition to the states of higher energy.

The importance of the probability factor is still further emphasized in the result that the sharp subordinate series 1π–$m\sigma$ and $1P$–mS are not absorbed, while the diffuse series 1π–$m\delta$ and $1P$–mD are absorbed. Both series have the same initial states so the difference in the absorption can be due only to the difference in the probability of the transitions.

A study of the absorption of the different spectral lines in a gaseous discharge, under varying conditions, should throw some light on the complicated phenomena. In most considerations of gaseous discharge, the possible influence of excited atoms is neglected. In considering the striated discharge in low-voltage discharge tubes, it was pointed out that impurities may affect the length of life of the excited atoms.[2] This appears to be confirmed to some extent by the results of the present work.

In addition to the preceding, a successful attempt has been made to photograph resonance radiation in the weakly excited helium. Care was taken to eliminate scattered light and the excited helium was strongly radiated with light from a second tube filled with helium. After proving that the scattered light from the second tube was inappreciable, it was found that the intensity of the 3889 Å line was greatly increased by the action of the radiation from the second tube. This must be due to resonance of the excited gas, produced by light of the same wave-length from the exciting tube. Paschen observed the same phenomenon for the first line of this series, but this appears to be the first photographic record of combined electrical excitation and resonance.

The structure of the 3889 line, studied by means of a quartz Lummer Gehrcke plate with the discharge tube cooled in liquid air, has been found to consist of at least two components. A weak component was found 0.044 Å to the short wave-length side of the main component. Photographs representing the structure of this line as well as the other results obtained are being published with the experimental work.

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[1] McCurdy, *Nature*, p. 122, January 23, 1926.

[2] McCurdy, *Phil. Mag.*, **48**, p. 898, 1924.

THERMODYNAMIC DERIVATION OF A BLACK BODY RADIATION ISOTHERM

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With the aid of thermodynamic considerations it is intended to show that Wien's Displacement Law and an additional assumption are sufficient to define the equilibrium state of a system. It is further shown, that this system then will obey Stephan-Boltzmann's Law and that the previous additional assumption is the thermodynamic explanation of the constancy of h—Planck's constant.

Let us consider a process

$$A \longrightarrow B - Q \qquad (1)$$

connected with the absorption of heat Q. We shall imagine it to be an ideal process of evaporation: i.e., the solid and the gas will be immaterial, therefore the volume of the solid will be negligible as compared with the volume of the gas; the gas will have a definite equilibrium pressure for