# THE SPECTRA OF GASES LIGHTED WITH STRONG ELECTRICAL DISCHARGES*

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Abstract

Spectra of condensed discharges through hydrogen at pressures up to several cm of mercury showed, as usual, the Balmer lines merging into the continuous spectrum. With increasing strength of the discharge the Balmer lines widened, the higher members of the series disappeared and the continuous spectrum became more intense, until with 1 microfarad at 15 kilovolts there were no Balmer lines left at all, only the continuous spectrum and some absorption lines due to aluminum from the electrodes, etc. Helium, oxygen and nitrogen exhibited similar changes, i.e., with increasing intensity of the discharge in helium the lines gave way to a continuous spectrum, and in oxygen and nitrogen the molecular bands gave way to spark lines and these in turn to a continuous spectrum. The continuous spectra from all the gases were alike. The intensity distribution across the continuous spectrum was rather even and hardly that of a black body. In the strong discharges the external characteristics of the atoms were pretty well effaced and the conditions perhaps approached those in the interior of a star.

IT IS known that the spectrum of a gas varies with the pressure of the gas and with the type of electrical excitation, for example, the Balmer lines of hydrogen broaden with increasing pressure and intensity of the discharge. The experiments described in this paper were undertaken to find out what the spectrum of the gas is like when very strong discharges are used.

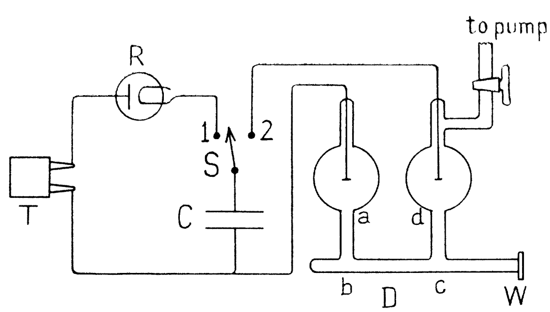


Fig. 1. Apparatus for sending strong discharges through the tube $D$.

A discharge tube $D$, Fig. 1, was arranged to be excited either directly by a 15000 volt, 25 cycle transformer $T$, or by a 0.002 microfarad condenser in series with a quenched gap to insure abrupt discharges, or by a 1 microfarad condenser. Fig. 1 gives a diagram of the apparatus for the last case.

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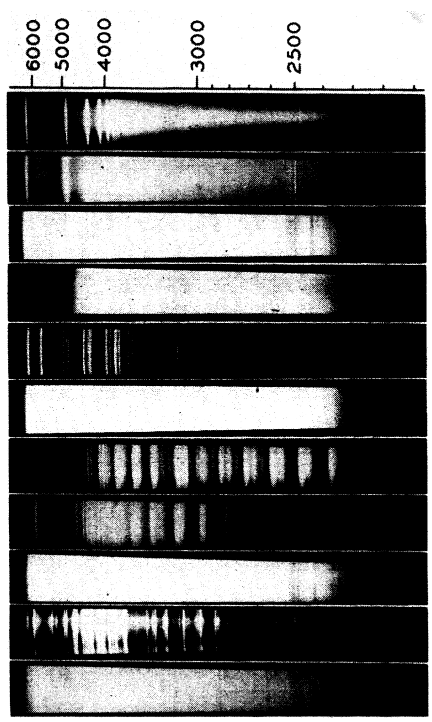
With the switch $S$ in position 1 the transformer $T$ charged the condenser $C$ through the rectifier $R$. When the switch was thrown quickly to position 2 by means of a spring the condenser discharged through the tube $D$. The arrangement was essentially that used by Anderson in his experiments with exploded wires.[1] The discharge tube was of glass with aluminum electrodes, the bulbs around the electrodes being about 5 cm in diameter. Sections *ab* and *cd* were 6 cm in length and *bc* was 7 cm in length and of internal diameter less than 1 cm. The light coming end-on through the quartz window *W* was photographed with a small quartz spectrograph. The discharge of the 1 microfarad condenser through the tube produced a blinding flash of light




| | | pressure mm of Hg | type of discharge |
|---|---|---|---|
| a | hydrogen | 60 | 0.002 mfd |
| b | hydrogen | 35 | 1 mfd |
| c | hydrogen | 60 | 1 mfd |
| d | hydrogen | 58 | uncondensed |
| e | helium | 30 | 0.002 mfd |
| f | helium | 30 | 1 mfd |
| g | nitrogen | 68 | uncondensed |
| h | nitrogen | 31 | 0.002 mfd |
| i | nitrogen | 35 | 1 mfd |
| j | oxygen | 35 | 0.002 mfd |
| k | oxygen | 35 | 1 mfd |

Fig. 2. Spectra of gases under various types of discharge.

and a fairly loud crack of sound, not so loud perhaps as the noise of an exploded wire. Usually a single discharge was sufficient to record the spectrum down to λ2000A in the ultra-violet. The pressure pulse in the tube sometimes blew off the quartz window, which was sealed on with wax. After a considerable number of discharges there were many fine superficial cracks on the interior surface of the portion *abcd* of the tube. None of the tubes, however, were broken by the violence of the discharge.

Some of the spectra of hydrogen, helium, nitrogen and oxygen are given in Fig. 2. Using the 0.002 microfarad condenser discharge the Balmer lines

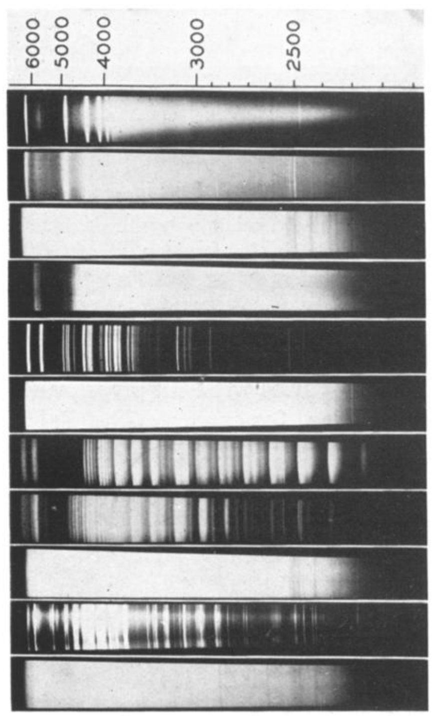
[1] Anderson, Astrophys. J. **51**, 37 (1920); Smith Astrophys. J. **61**, 186 (1925); Anderson and Smith, Astrophys. J. **64**, 295 (1926).

of hydrogen widened with increasing pressure, as in strip *a* Fig. 2, the members of the series below $H_7$ disappeared and the continuous spectrum increased in intensity. With the 1 microfarad condenser and a discharge tube of 8 mm internal diameter between *b* and *c*, Fig. 1, there were only four Balmer lines left, these being much widened, and the continuous spectrum was intense, as in strip *b*. With the 1 microfarad condenser and a discharge tube of 4 mm internal diameter between *b* and *c*, Fig. 1, there were no Balmer lines left at all, only the continuous spectrum, as in strip *c*. The continuous spectrum was crossed by a few absorption and emission lines. Most of these were aluminum lines, but not all of them were identified. The spectra with the 1 microfarad condenser discharges were much the same for gas pressures from 20 to 60 mm of mercury, as might be expected on the idea that under such violent excitation the momentary pressure in the path of the discharge was very high and not dependent to a great extent on the pressure of the cold gas. Pressures greater than about 80 mm of mercury could not be used, for at greater pressures the discharge would not pass through the tube with the potentials available. It is interesting to compare strip *c* with strip *d* which is the spectrum of an uncondensed discharge through hydrogen at a pressure of 58 mm of mercury. This appears, except for its weakness at wave-lengths greater than 5000A, much like strip *c*. The conditions of excitation of the gas for the two spectra were as different as could well be imagined, the one being a brilliant flash and the other a gentle blue glow, and yet the continuous spectra are somewhat similar.

Helium, nitrogen and oxygen, strips *e* to *k*, Fig. 2, exhibited changes similar to those of hydrogen, i.e. with increasing intensity of the discharge in helium the lines gave way to a continuous spectrum, and in oxygen and nitrogen the molecular bands gave way to spark lines and these in turn to a continuous spectrum. The continuous spectra from all the gases with the 1 microfarad condenser discharge were closely alike. A comparison with the lines of a mercury spectrum whose intensities were known[2] showed that the distribution of intensity across the continuous spectra was constant within two, and probably one, orders of magnitude from λ6000 to 2000A. Thus, within the fairly large error of measurement, the intensity distribution did not seem to be that of a black body.

The general result of the experiments appeared to be that under the strong discharges the external characteristics, such as energy levels, etc., of the atoms of the gases were pretty well effaced. The atoms could no longer radiate their usual line or band spectrum but only a continuous spectrum. We may imagine that the conditions approached those in the interior of a star. It seems difficult at the present time to form a satisfactory quantitative theory of the continuous spectrum. In trampling on the atom we have at the same time trampled on theories of atomic behavior. It is hoped to extend the investigation using greater dispersion.

[2] Hulburt, Phys. Rev. **32**, 593 (1928).

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