TRANSIENT RADIATION PROCESS IN GAS DISCHARGES

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In 1944 Lord Rayleigh published a report of experiments intended to measure the life-time of excited atomic states in hydrogen. He used an electrodeless discharge in a ring-shaped tube and measured the rate of decay of the luminosity in a side arm attached to the ring. At each discharge a jet of luminous gas appeared in the side arm and seemed to travel down it. His results were in sharp disagreement with the theoretical values for the relaxation times for excited atoms; he found a mean life-time of approximately $1/10^5$ seconds instead of the expected $1/10^8$ seconds. At the University of Oklahoma work has been carried on since 1948 in an attempt to explain the discrepancy between theoretical and actual times found in experiments such as Rayleigh's. This paper is a report of the latest work with special attention given to the discovery of intense radiation in the continuum associated with the Balmer series.

EQUIPMENT. In the latest work a discharge tube shaped like a T having aluminum electrodes in the ends of the crosspiece was used. Condensers of 6 or 12 microfarads capacitance were charged to 2, 3, 4, or 5 thousand volts and then discharged suddenly through a vacuum switch through the discharge tube. Light emitted in the head of the tube and down the side arm passed through a narrow slit parallel to the side arm. Part of it fell upon a spectograph and part went through a lens to a rotating mirror and thence to film. Pictures were taken at pressures ranging from .2 to 5 mm. Hg.

RESULTS. From the known dimensions of the optical system and the angular velocity of the rotating mirror, the velocity of advance of the luminosity could be determined approximately. Values range from 6 to 27 x 10^5 cm/sec with most of them lying in the region near 10 x 10^5 cm/sec. Velocities increased for increase in potential across the condensers and for decrease in pressure within the tube.

The rotating mirrorgrams indicate that as luminosity moves down the side tube there is a region of maximum intensity behind which intensity decreases. In other words, a front of excitation appears to travel down the tube.

Study of rotating mirrorgrams taken with filters of nickel oxide glass which passed only the lines and continua below the eighth Balmer line and of sodium nitrite solution which passed only the upper five Balmer lines, reveal that the forms of the front emitting the Balmer lines and the front emitting the continuum are essentially the same, and that the velocities of advance down the tube of the fronts emitting the two types of luminosity are equal. Pictures taken using both filters at once, one on the upper part of the slit and one on the lower part, reveal that there is no appreciable time lag (not more than $1/10^7$ seconds) between the appearance of the two types of radiation, and that the duration of the two types of emission is approximately the same —of the order of one microsecond. It seems from blackening on the film that the energy in the continuum radiation is of the same order of magnitude as that in the line series.

It is believed that the continuum observed is that due to electronic recombination. The molecular continuum, if present, should overlap the Balmer lines and should decrease in intensity at low pressures; the observed continuum, however, does not overlap the lines at all and increases in relative intensity at lower pressures.

There seems to be no escape from the conclusion that the luminosity observed from the side tube is produced there and is not, as Rayleigh thought, due to an overflow of excited gas from the discharge arm. Apparently, also, recombination as a process contributing to radiation in such discharges is much more important than has been indicated in the literature.

Not enough is known yet about the electrical properties of the circuit and about the pressure differences existing within the tube after discharge to permit a definite description of the mechanism producing excitation in the side tube, but something of the nature of a shock wave seems likely. Work is continuing at the University of Oklahoma along two lines: study of the electrical properties of the discharge, and study of the radiation below the 3000 Angstrom limit imposed by the Pyrex tubing used previously.