Recombination in Pulsed Gas Discharges

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The fact that recombination is possibly one of the important factors in the production of the luminosity in pulsed gas discharges was suggested by Goldstein (3) in 1948. Later Clotfelter (2) found unquantized emission belonging to the Balmer series. Atkinson (1) in spectrographic investigations of the ion concentrations in the side arm of the discharge tube noted that the point of maximum luminosity corresponds closely with the point of maximum ion concentration. In addition, the luminosity lifetime of 10^{-6} seconds for the discharge, compared to 10^{-8} seconds as the probable lifetime of excited states, also suggests a high degree of ionization, thus increased probability of recombination. An extended investigation for a more precise relation between the ion concentration and the intensity is discussed below.

The Hβ line was chosen to make measurements on because it was quite intense and convenient for observation. The microphotometer trace of the Hβ line was transferred to exposure plots from which the intensity and the ion concentrations could be determined.

The ion concentrations were measured in the same way that Atkinson (1) determined them; i.e., using the derivation by Holtsmark (4) that the broadening of a spectral line produced by ions is proportional to $N^{2/3}$ where N is the ion concentration. Or inversely N is proportional to $d^{3/2}$ where d is the half-intensity breadth of the spectral line. The half-intensity breadths were determined by firing a sequence of flashes, say 2, 4, 8, 16, and 32, from which, by assuming the exposure for two flashes was twice that for one flash, one could measure and compare half-intensity breadths directly from the microphotometer traces.

The area under the trace when plotted as exposure rather than as blackening of the plate is a measure of the exposure, E, and dividing by the exposure time which is effectively the number of flashes, n, one obtains the intensity of the discharge for a given flash. This relation is based upon the reciprocity law which will hold for high intensities and short exposure times with considerable accuracy. Since *all* the exposures made were of intermittent flashes, there need be no correction for the intermittency effect.

The area under the contour was found to be proportional to the central height, h, times the half-intensity width, d. This has been shown to be true for many similar known functions such as e^{-x^2}, $e^{-|x|}$, $1/(x^2+a^2)$ with a single parameter and indeed a semi-log plot of two of the curves shows the contours approach very nearly a gaussian distribution. Thus hd/n is then a measure of the intensity.

The above derivation did not account for the possibility that the emitting systems may be in motion past the slit of the spectograph. Assuming the process is that of recombination, that a cloud of electrons moves past the slit with velocity, v, and that the intensity falls off to zero immediately after the cloud passes, one can then weight the intensity with a velocity correction and the intensity is proportional to hdv/n.

The resulting log-log plot of the thus determined ion concentration and intensities showed a definite discontinuity between the data obtained from two capacitors. It was found that either the assumption for the velocity correction was erroneous or that the emitting systems were stationary. Without the velocity assumption three sets of data plot very nearly as straight lines with slopes of 1.86, 1.80 and 1.93. The last value was obtained at a later date with better observation. Weighting these accordingly the slope is approximately 1.9. Accordingly the relation is I is proportional to $N^{1.9}$.

The number of positive ions per unit volume, N^{+}, should equal the number of electrons per unit volume, N^{-}, as shown in early work by Kenty(5). The diffusion of highly mobile electrons toward the walls of the tube will create a space charge and thus pull the positive ions along and so retard the electrons. This will keep the concentrations equal.

The probability of an act of recombination will be proportional to both the number of electrons and the number of positive ions present in a given volume, and since the intensity will be a measure of the number of acts of recombination, one can conclude that I is proportional to $N^{+} \cdot N^{-} = N^{2}$.

The agreement of the measurements with that of the recombination theory gives evidence that the process of luminosity production in the pulsed gas discharge may be recombination.

LITERATURE CITED

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