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LETTER TO THE EDITOR

ATOMIC-STATE POPULATION OF Ne METASTABLES IN THE DISCHARGE OF A Ne — Br_2 MIXTURE

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Mixtures of inert and halogen gases have been extensively studied in view of their application in detectors of ionizing radiation[1,2] and laser systems[3].

Spectral analysis[4] reveals the electronegative action of Br and second-order collisions occurring between Br and Ne metastables. To gain a more complete insight into this problem, we made an attempt to determine the atomic-state population of Ne metastables in a Ne — Br_2 mixture.

The method used was based on the self-absorption of the optical line within a discharge tube[5]. A discharge tube with three electrodes was employed. The emission of light from section AB of the tube of length l and from section AC of length l' (Fig. 1) from the positive column of the Ne — Br_2 discharge was investigated. Assuming that the observed line has a Doppler profile, the density N of the absorbing atoms, may be determined by the relation[6]

$$N = 8.64 \cdot 10^{13} (k_0/\lambda f) (T/M)^{1/2}, \qquad (1)$$

where k_0 is the absorption coefficient, λ is the wavelength in Å of the line under consideration, f is the absorption oscillator strength of the transition, T is the absolute temperature, and M is the atomic weight. The ratio of the

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flux reaching the slit of the monochromator S from sections AC and AB in Fig. 1 is[5]

$$\frac{I_{AC}}{I_{AB}} = \frac{\int\limits^{\omega} \{1 - \exp[-k_0 l' \exp(-\omega^2)]\} d\omega}{\int\limits^{\omega} \{1 - \exp[-k_0 l \exp(-\omega^2)]\} d\omega}, \quad (2)$$

where $\omega = [2(\nu - \nu_0)/\Delta\nu_D](\ln 2)^{1/2}$. ν_0 is the frequency at the line centre. The Doppler breadth[6] is

$$\Delta\nu_D = [2(2R\ln 2)^{1/2}/c]\,\nu_0\,(T/M)^{1/2},$$

where R is the gas constant and c is the velocity of light.

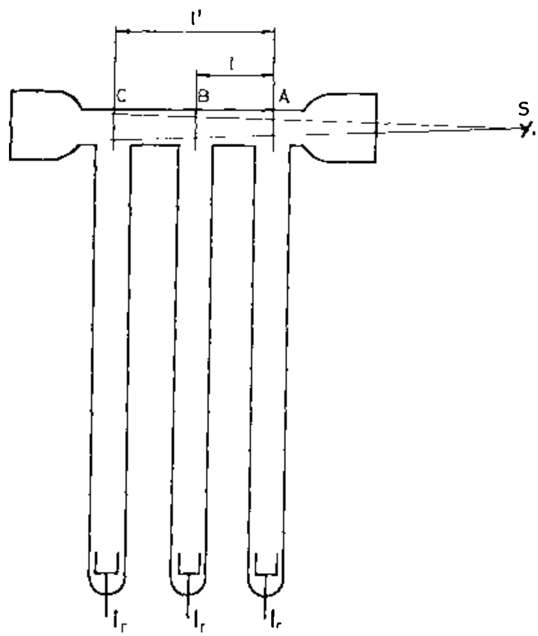

Fig. 1. Diagram of the discharge tube.

In the present work the length $l' = 9$ cm $= 1.9\,l$. The discharge temperature was approximately 400 K. The values of $k_0 l$ obtained from Equ. (2) for the various ratios I_{AC}/I_{AB} are shown in Fig. 2.

A tube with three Iridium electrodes was used (Fig. 1); it was filled with a Ne-Br_2 mixture at partial Ne pressures of 9 Torr and 30 Torr. The partial pressure of saturated Br vapours was 0.03 Torr when the cooled end of the tube was at a temperature of -57.4°C[7].

The lines have been recorded using the standard spectroscopic arrangement by the lock-in technique.

In the present experiment, the current strength in the circuit of the discharge tube was varied up to a maximum of 16 mA. The densities N from Equ. (1) were obtained using the ratios of fluxes I_{AC}/I_{AB} of the NeI line at 7032 Å (for the $1s_5$ — — $2p_{10}$ transition) and the corresponding calculated values for k_0 (Fig. 2). The f value of 0.0854, obtained by Wiese[9], was used in the calculation.

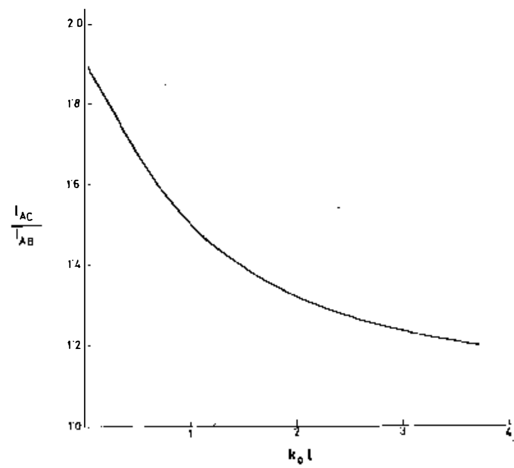

Fig. 2. Variation of kl with the intensity ratio I_{AC}/I_{AB}.

Fig 3. shows densities of Ne metastables for two different partial pressures of Ne and the constant pressure of Br.

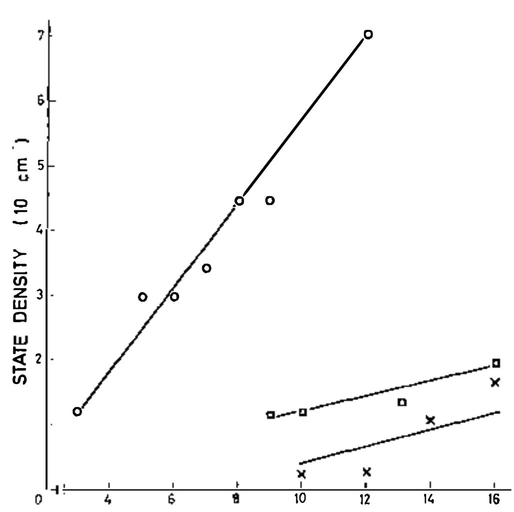

Fig. 3 State density of Ne metastables vs. discharge current in a Ne-Br_2) mixture. ○ $P_{Ne} : P_{Br2} = 1000 : 1$, glow discharge; □ and × $P_{Ne} : P_{Br2} = 300 : 1$, □ stationary glow discharge and × striation discharge.

At a ratio of partial pressures P_{Ne} : P_{Br2} of 300 : 1 in the current region under consideration, a stationary glow discharge or a striation discharge can be maintained. Measurements were performed in both discharges. In the case of the striation discharge densities attain values which are lower than those in a stationary discharge. It may be concluded that in this case the quenching of Ne metastables by ionization of Br is more efficient due to the stronger total electrical field between striations. In both discharges the density attained a value of approximately $1 \cdot 10^{11}$ cm^{-3}.

For a higher ratio of partial pressures, 1000 : 1, a stationary discharge appears, and the density increases with increasing current from $1 \cdot 10^{11}$ to $7 \cdot 10^{11}$ cm^{-3}. Errors in measurement can be as large as 30%.

Comparison with the results obtained for ratios of partial pressures of 300 : 1 and 1000 : 1 shows that the density of Ne metastables decreases with decreasing ratio. It may be concluded that the effect of Penning ionization is less pronounced in a mixture with higher density of Ne atoms.

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