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A STUDY OF THE RADIAL DISTRIBUTION OF THE ULTRAVIOLET RADIATION FROM HOLLOW CATHODE GLOW DISCHARGE[1)]

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An energetic neutral flow (metastable atoms and ultraviolet radiation) effusing from the negative glow of the hollow cathode discharge through a small orifice (diameter 85 μm) into a high vacuum region was studied by the time-of-flight method. The hollow cathode could be displaced against the effusing orifice. Spectroscopically pure neon was used and the measurements were made at a pressure range of 30—500 Pa, for a discharge current from 2 mA to 10 mA. Under our experimental conditions no signal corresponding to metastable atoms was observed.

ИЗУЧЕНИЕ РАДИАЛЬНОГО РАСПРЕДЕЛЕНИЯ УЛЬТРАФИАЛЕТОВОГО ИЗЛУЧЕНИЯ НА ОСНОВЕ ТЛЕЮЩЕГО РАЗРЯДА В ПОЛОМ КАТОДЕ

В работе на основе времени пролета проведено исследование высокоэнергетического нейтрального потока (метастабильных атомов и ультрафиолетового излучения), вытекающего из катодного свечения от разряда в полом катоде через малое круглое отверстие (диаметр 85 мкм) в область высокого вакуума. Полый катод при этом должен быть расположен прямо напротив круглого отверстия. В эксперименте использовался чистый неон и измерения проводились при давлениях 30—500 Па для разрядного тока от 2 мА до 10 мА. В данных экспериментальных условиях не обнаружено никаких данных о наличии метастабильных атомов.

I. INTRODUCTION

A positive column of the glow discharge was observed [1] to be an efficient source of the effusing energetic neutral flow (metastable atoms, ultraviolet

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radiation). The energetic neutral flow effusing from a positive column was studied in our previous papers [2, 3, 4, 5, 6]. The experimental arangement used gave information about the flux density of particles at the wall only. Generally, an estimation of reaction rates of various elementary processes requires a radial variation of the flux density to be known, too. For this purpose we have used a radially displaceable hollow cathode as in [12] for ion-molecular reactions.

II. EXPERIMENTAL METHOD

Information about the distribution of the effusing flow from negative glow can be obtained by means of a discharge tube with a displaceable hollow cathode. The geometry of this tube was suggested in such a way as to suit the experimental apparatus [8]. A detail of the experimental apparatus with the hollow cathode discharge tube is schematically shown in Fig. 1.

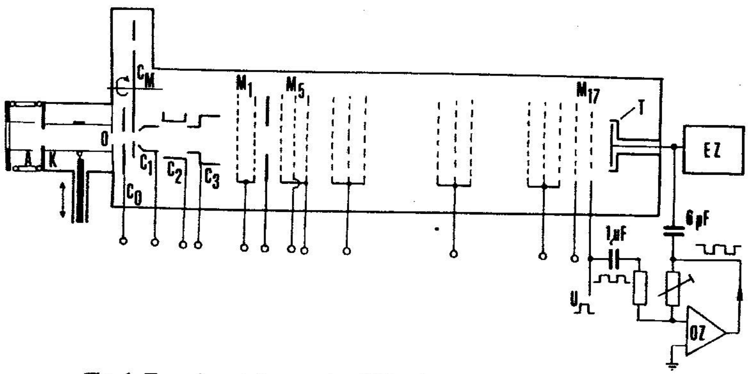

Fig. 1. Experimental apparatus. EZ – electrometer, OZ – amplifier.

The excited atoms, charged particles, ultraviolet radiation and groundstate atoms passed from the hollow cathode K (inner diameter 11 mm, length 40 mm) through a small orifice 0 ((85 μm diameter) in the extraction electrode into a high vacuum region. Any charged particles present in the beam were removed by retarding fields [2]. The effusing beam was chopped by a rotating disc C_M to separate contributions of the ultraviolet photons and metastable atoms in the collector current by the time-of-flight method [8]. The metastable atoms passed through the drift space (31 cm length) with a delay corresponding to their thermal velocities. On the other hand photons passed through the drift space with negligible transit time. After passing through the drift space the particles (photons and metastables) were detected in the gated detector by means of the electron emission when the

metastable atoms and photons struck a metal surface [5]. The gated detector consisted of a molybdenum collector and a control grid M_{17} placed in front of the collector. The ejected electrons from the collector due to the metastables or photons could be accelerated to grid M_{17} by a positive gating pulse, and so the current to the collector could be measured at any desired time after the chopping pulse.

III. RESULTS AND CONCLUSIONS

In the case of a positive column of the glow discharge in neon and argon a signal corresponding to the metastable atoms in the collector circuit was observed [5].

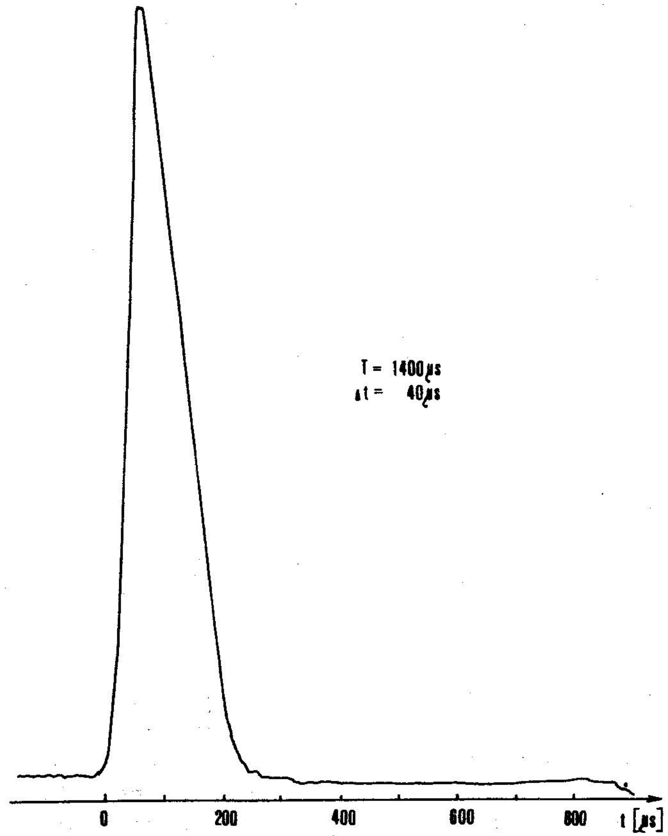

Fig. 2. Collector current (ultraviolet radiation) as a function of the transit time t for the neon discharge at a pressure of 85 Pa and a discharge current 4 mA, after accumulation of 100 transit time spectra. T – chopping period, Δt – gating pulse duration.

Despite of the fact that the hollow cathode discharge is often considered as a rich source of the metastable atoms [7, 9, 10], no signal corresponding to the metastable atoms was obtained in our experiment. Spectroscopically pure neon was used. The steady state discharge was produced at various pressures in the range of 30—500 Pa and a discharge current from 2 mA to 10 mA. The sensitivity of the applied method was increased by using an accumulative technique (Multichanel analyser NTA 1024). We have accumulated 100 transit time spectra as is illustrated in Fig. 2. It can be seen that no signal corresponding to the metastable atoms is present. A considerable number density of the metastable atoms would cause a collector current delayed by approximately 360 μs against a maximum of the ultraviolet radiation pulse. We have concluded that the metastable atoms were deexcited by the Penning ionization due to collisions with metal vapor in the cavity of the cathode. Therefore we consider now only the signal from the ultraviolet radiation below the threshold wavelength of 290 nm (Mo collector).

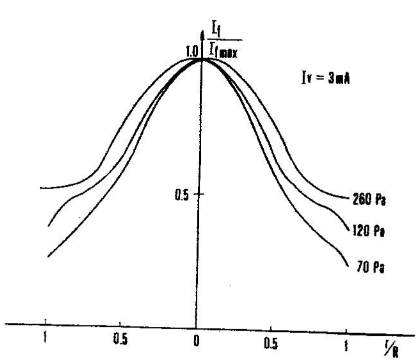

Fig. 3. Radial profile of the integral intensity of the u-v radiation for various pressures.

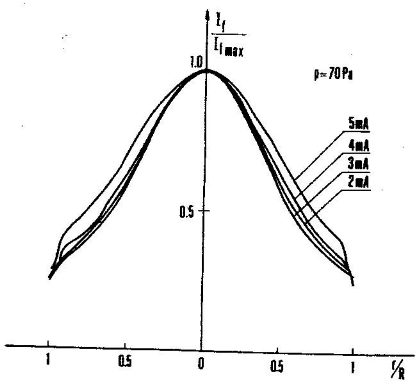

Fig. 4. Radial profile of the integral intensity of the u-v radiation for various discharde currents.

The radial profiles of the normalized integral intensity of the ultraviolet radiation as a function of the pressure and discharge current are presented in Figs. 3 and 4. The variation of the discharge parameters can be seen to have an influence on the flux mainly in the region of the glow edge. The observed profile of the radial integral intensity of the ultraviolet radiation varies with the discharge current in a similar way as in the case of He II line (486.6 nm) [11]. The nonzero value of the collector current in the region of the cathode dark space probably corresponds to photons from the immovable anode A of the discharge tube. A spurious effect can also arise from the small angular resolution of the detector system (±2.8°).

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