Physics

K. I. ROZGACHEV and V. A. FABRIKANT

1957

SovietRxiv

Abstract

Full Text

Physics

K. I. ROZGACHEV and V. A. FABRIKANT

ON STEPWISE EXCITATION OF ATOMS

(Presented by Academician M. A. Leontovich, January 9, 1957)

Until now there have been only indirect experimental data on processes of stepwise excitation of atoms by electron impacts ([1]). Theoretical estimates of the probabilities of processes of stepwise excitation are approximate in character ([2]). In these processes, a previously excited atom undergoes an inelastic collision with an electron, which transfers this atom to a higher energy level. The excitation potential of an already excited atom may be considerably lower than the potential of direct excitation. This latter circumstance leads to the fact that, in processes of stepwise excitation to the upper energy levels, a much larger fraction of all the plasma electrons of the discharge should participate than in processes of direct excitation. In addition, the effective cross section of an excited atom should exceed the effective cross section of a normal atom. All this makes the role of stepwise processes in a gas discharge very important.

The aim of the present work was the direct experimental proof of the existence of processes of electronic stepwise excitation and the determination of the parameters characterizing these processes. Our experiments are an electronic analogue of the well-known experiments of Füchtbauer and Wood on stepwise optical excitation of atoms ([3]).

As the object of study we chose the visible triplet of mercury (5461; 4358; 4047 Å), with an excitation potential of 7.73 eV (level 7^3S_1). In this case, stepwise excitation is possible from the levels $6^3P_{0,1,2}$ and 6^1P_1. Especially large concentrations of atoms must be present at the metastable levels $6^3P_{0,2}$.

Mercury atoms can be excited to the $6P$ levels either by electron impacts or by irradiation with resonance lines. The second method has a number of advantages, but is associated with a complication of the experimental technique, and therefore will be used by us later.

In the present work the first method was applied. The experimental tube with an electron gun producing slow electrons had a design proposed by Hanle and Schaffernicht ([4]). The radiation of the visible triplet was recorded with an ISP-51 spectrograph both photographically and by a 13-stage photomultiplier with an antimony–cesium cathode. The photocurrents were amplified according to the DuBridge–Brown circuit with an EM-4 tube. The maximum electron energy was controlled by the retarding-field method.

Fig. 1. Dependence of photocurrent on electron energy

Figure 1: Fig. 1. Dependence of photocurrent on electron energy

To observe stepwise processes, one should either increase the current strength or increase the pressure of mercury vapor in the experimental tube. Our experiments showed that good results are obtained by increasing the pressure to 0.5–1 mm Hg. At such pressures and with collector currents of the order of 5–10 μA, a clear effect of stepwise excitation was obtained.

In Fig. 1 one of the experimental curves for the green line 5461 Å is shown. The electron energy is plotted along the abscissa, and the photocurrent in relative units along the ordinate. A weak glow was observed beginning at approximately 5 eV.

The entire part of the curve lying to the left of 7.73 eV corresponds to acts of stepwise excitation in pure form. The steep rise of the curve at energies exceeding 8 eV is explained by the rapid increase of the effective cross section for direct-excitation processes.

The position of the maximum is shifted somewhat to the right in comparison with the maximum of the excitation function of the level 6^3P_1 (6.6 eV), which is quite natural. A detailed analysis of the shape of the curve is made difficult by the fact that the exact excitation functions of the levels $6^3P_{0,2}$ and 6^1P_1 are unknown.

Preliminary measurements showed that the intensity of the lines of the visible triplet increases in the region of stepwise excitation approximately quadratically with increasing current. Such a regularity was to be expected for a constant lifetime of the atoms at the $6P$ levels.

Fig. 1. Dependence of the photocurrent on the electron energy

Moscow Power Engineering Institute
named after V. M. Molotov

Received
7 I 1957

CITED LITERATURE

1. V. Fabrikant, F. Butaeva, I. Tsirt, ZhETF, **8**, 35 (1938); V. Fabricant, F. Butaeva, I. Zingg, Sow. Phys., **13**, 23 (1938); H. Massey, E. Burhop, *Electron and Ionic Impact Phenomena*, Oxford, 1952, p. 68–71.

2. B. Ya. Vorskii, ZhETF, **17**, 315 (1947).

3. C. Füchtbauer, Phys. Zs., **21**, 635 (1920); R. Wood, Phil. Mag., **50**, 775 (1925); **4**, 466 (1927).

4. W. Hanle, W. Schaffernicht, Ann. Phys., **6**, 905 (1930).

Note: Figure translations are in progress. See original paper for figures.