TIME DEVELOPMENT OF THE SHOCK WAVE IN THE PLASMA PARALLEL PLATE ACCELERATOR[1])

PÍCHAL, J.,[2]) Praha

The time evolution of the plasma column moving in the plasma parallel plate accelerator was studied to verify the possibility of the application of the classical shock wave model for the description of shock waves in the parallel plate accelerator

I. INTRODUCTION

This paper deals with the time development of the shock wave formed during the plasma column motion in the plasma parallel plate accelerator. As known, the structure of the plasma column front is determined by transfer energy processes between the particles of the plasma column and the rest gas filling the discharge chamber of the plasma accelerator [1, 2]. This energy transfer can occur by two kinds of mechanism — by ionization and by simple particle collisions. When no ionization effects occur, the structure of the shock front is determined by the dissipative processes of neutral particles and its form is very nearly similar to the form of the classical shock wave. In the second case, when the energy transfer is caused first of all by ionization, the density of the charged particles within the shock wave increases until the structure is almost determined by the dissipative processes of the charged particles and a fast joining of the plasma column front with the layer of the rest gas occurs.

To verify the possibility of applying this shock wave model also to the description of shock waves forming in the plasma parallel plate accelerator, the time development of the plasma column was studied by measuring the intensity of light radiation of the plasma column during its motion in the plasma accelerator. In the present report some experimental results are described.

[1]) Contributions presented at the 6th Symposium on Elementary Processes and Chemical Reactions in Low Temperature Plasma, JELŠAVA–HRÁDOK, June 9.—13. 1986

[2]) Czech Technical University Prague, Department of Physics, Suchbátarova 2, 166 27 PRAHA 6, Czechoslovakia

II. METHOD

For the above mentioned experiments, an adapted plasma parallel plate accelerator was used [3]. The time distribution of the light intensity radiated by the plasma was measured in some detail for different voltages of the power supply (condensor battery) feeding the accelerator along the axis of the interelectrodal space. The light radiated by the plasma was conducted to the photomultipliers by fiber optics. The time distribution of the electric signal of the photomultiplier was intercepted photographically from the screen of the oscilloscope and the obtained time characteristics of the photomultiplier's electric signal were statistically processed (fig. 1).

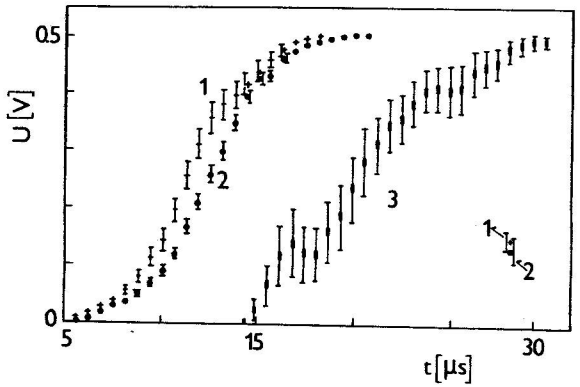

Fig. 1. Results of experiments at a distance of 28 cm from the discharge ignition point. Initial power supply voltage 1—8 kV, 2—6 kV, 3—4 kV.

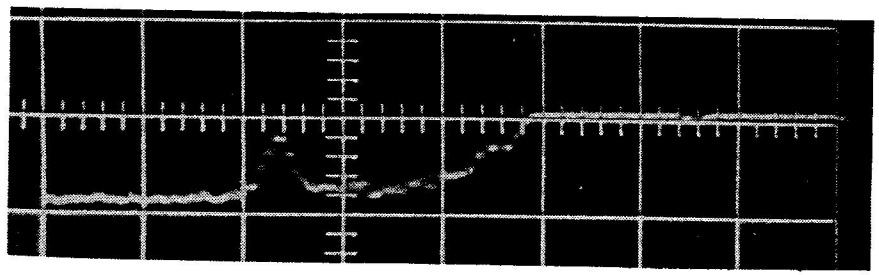

Fig. 2. Example of the time characteristic of the photomultiplier's electric signal. Distance of 28 cm from the discharge ignition point (end of electrodes). Power supply voltage 2 kV, initial pressure in the chamber 2.8×10^{-3} Pa, 0.5 V/div, 5 μs/div.

III. RESULTS

The results of the experiments prove that there are two different mechanisms forming the plasma column front in the parallel plate accelerator. If the energy exchange by impacts without any ionization between the atoms of the rest gas and the plasma column particles prevails, the plasma column can be detached from the layer of the compressed rest gas, which resembles by its behaviour and characteristics a classical shock wave (fig. 2).

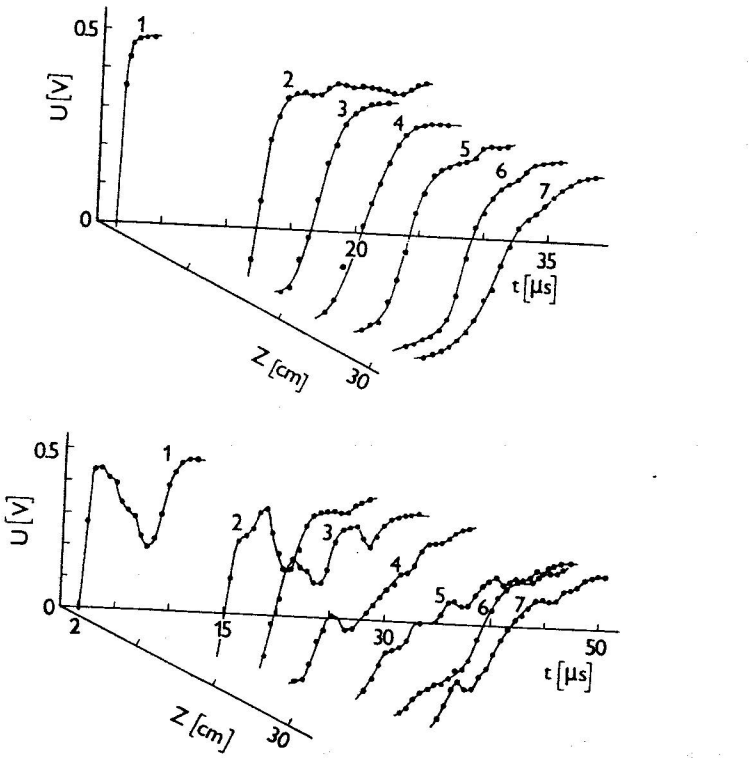

Fig. 3. Time development of the shock wave at distances of 1—2 cm, 2—10.5 cm, 3—14 cm, 4—18 cm, 5—22 cm, 6—26 cm, 7—28 cm from the discharge ignition point. Initial power supply voltage a) 8 kV, b) 4 kV.

If the energy exchange by ionization prevails between the particles or atoms, a fast joining of the plasma column front with the layer of the rest gas occurs and clearly there is no detached shock wave moving before the plasma column front (fig. 3a).

There was also found a mechanism of the plasma column front forming probably corresponding the transition between the state when the energy exchange between the rest gas and the plasma particles occurs almost by impacts without any ionization and the state when the energy exchange by ionization prevails (fig. 3b). In comparison with the results obtained in the coaxial plasma accelerator [2], the mentioned mechanism of plasma column forming was not found in the coaxial accelerator.

IV. SUMMARY

There were found two different types of shock wave forming in the plasma parallel plate accelerator. It seems that the classical model of the shock waves may be appropriate also in the parallel plate accelerator.

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Received August 6th, 1986

ВРЕМЕННАЯ ЭВОЛЮЦИЯ УДАРНОЙ ВОЛНЫ В ПЛАЗМЕННОМ УСКОРИТЕЛЕ С ПАРАЛЛЕЛЬНЫМИ УСКОРЯЮЩИМИ ПЛАСТИНАМИ

В работе исследована временная эволюция плазменного столба, движущегося в ускорителе с параллельными ускоряющими пластинами. Целью статьи является проверка возможности применения классической модели для описания ударных волн в данном ускорителе.