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EQUIDENSITOMETRICAL STUDY OF PLASMOIDS ORIGINATING IN HIGH FREQUENCY PLASMA[1]

K. KAPOUN[2], Ostrava, B. GROSS[3], V. KAPIČKA[4], Brno, A. PETRAKIEV[5], Sofia

If the high frequency discharge burns in the direct current superimposed electric field, an electrical breakdown associated with the origination of plasmoids takes place. Analysis the pictures taken with the camera PENTAZET 16 we have measured the living interval of plasmoids at the breakdown in air, the diameter of plasmoids, the plasmoids mobility and dthe acceleration of plasmoids. The equidensitometrical analysis of these pictures gives a more exact data of the discharge geometry and the time dependence.

ЭКВИДЕНСИТОМЕТРИЧЕСКИЙ АНАЛИЗ ПЛАЗМОИДОВ, ОБРАЗНОВАННЫХ В ВЫСОКОЧАСТОТНОЙ ПЛАЗМЕ

При высокочастотном разгряде, происходящем в постоянном электрическом поле, имеет место электрический пробой, связанный с образованием плазмоидов. На основе анализа снимков, полученных при помощи фотоустройства PENTAZET 16, измерены время жизни плазмоидов при пробое в воздухе, диаметр, подвижность, а также ускорение плазмоидов. Эквиденситометрический анализ полученных снимков дает более точное представление о геометрии разряда и его временной зависимости.

I. INTRODUCTION

Parameters and properties of unipolar high frequency discharge change due to the superimposed d.c. electric field. If this field is strong enough, there occurs an electrical breakdown between the point electrode which burns on the high frequency discharge and the plane electrode supplied with d.c. voltage. This breakdown is associated at normal pressure with the origination of plasmoids, whose existence has been verified with the help of a high speed camera [1].

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[2] Katedra fyziky VŠB, Vítězného února, 708 33 OSTRAVA-PORUBA, Czechoslovakia.
[3] Katedra el. přístrojů, Elektrotechnická fakulta VUT, Obránců míru, 600 00 BRNO, Czechoslovakia.
[4] Katedra fyz. elektroniky, PF UJEP, Kotlářská 2, 600 00 BRNO, Czechoslovakia.
[5] Katedra optiky a spektroskopie, Fyzikální fakulta University v Sofii, SOFIA, Bulgary.

II. ELECTRICAL BREAKDOWN OF AIR IN SUPERIMPOSED FIELDS

To generate unipolar high frequency discharges we used a high frequency generator working on the frequency of 27.1 MHz provided with a high frequency wattmeter and a diode voltmeter for measuring the power yielded in the discharge and the high frequency voltage across the electrode. Above the point electrode at a distance of several centimeters there was a plane electrode supplied with d.c. voltage. The d.c. voltage source was a one-wave rectifier with a condenser. The power source sas connected without a current limiting resistor. The d.c. voltage was measured by an electrostatic voltmeter. The generator of unipolar high frequency discharges and the d.c. voltage source were earthed. The measurements were carried out at a pressure of 10^5 Pa in air as well as in nitrogen and argon.

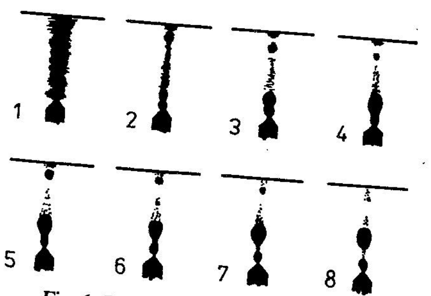

Fig. 1. Time evolution of plasmoids.

Using the PENTAZET 16 high speed camera with a frequency of 3000 pictures per second there was photographed a number of breakdowns on an ORWO NP 7 16 mm film. The pictures have shown that during the breakdown limited regions of plasma of approximately spherical proportions are forming whose evolution may take several hundreds of a seconds. These plasma configurations have been called plasmoids (Fig. 1) [1]. Numbers of breakdowns analysed under different conditions may allow several conclusions: the plasmoids are observed on application of strong d.c. electric field plasma (high frequency plasma); the breakdown is always associated with the origination of plasmoids occurring just before and after the real breakdown; the diameter of plasmoids is $2\times10^{-3}-10^{-2}$ m; the life time of plasmoids is of the order 10^{-2} s; the measured plasmoids have a maximum mobility rate of 4 ms^{-1}; the maximum acceleration value is 1500 ms^{-2}.

The conditions of breakdowns, their voltage and current courses were measured and the time shape of electron density value (orderly of 10^{22}—$10^{23}\,m^{-3}$) were evaluated. Then the spectral analysis of the breakdowns was performed and both the neutral gas (of the order 10^3K) and the electron temperatures (1—3×10^4K) [2, 3, 4] were calculated. Moreover, the approach to observe the time changes of

the thermal field within the environment of the breakdown by means of the Schlieren method has been suggested.

III. EQUIDENSITOMETRICAL ANALYSIS OF AIR BREAKDOWN PICTURES IN SUPERIMPOSED FIELDS

Equidensitometrical analysis of pictures obtained by a high speed camera represents another diagnostic method of air breakdown study. With the above

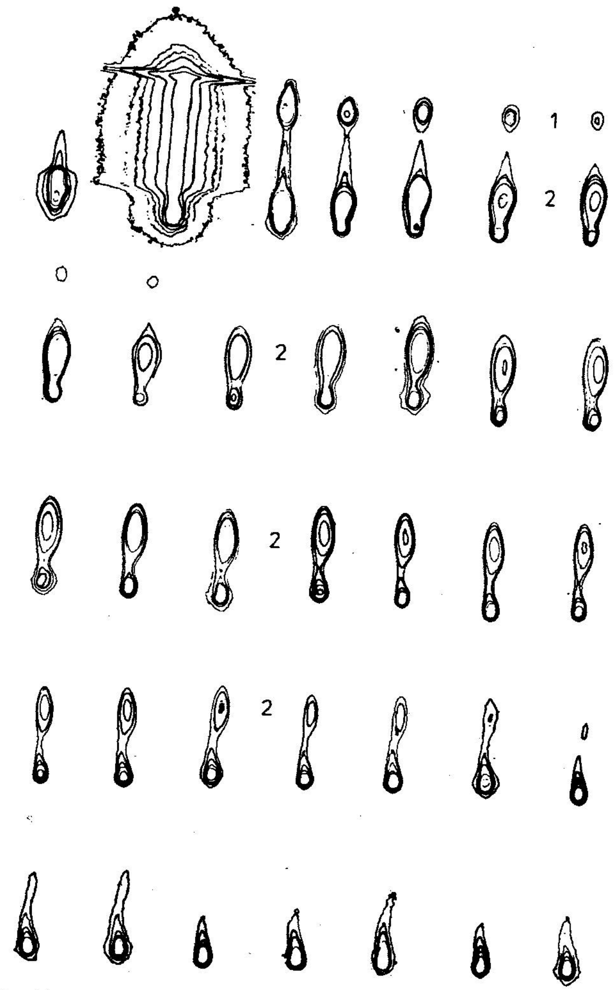

Fig. 2. Equidensities of pictures of plasmoid time evolution. Optical density $S \sim 0.1; 0.2; \ldots$

analysis we obtain equidensities, i. e. lines connecting the points of the same optical density of the analysed picture ($S = const.$)

The optical density depends on the emulsion the lighting and film processing qualities.

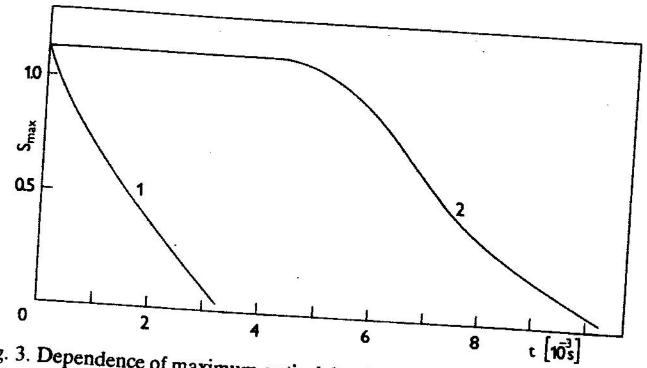

Fig. 3. Dependence of maximum optical density of pictures of plasmoids on time.

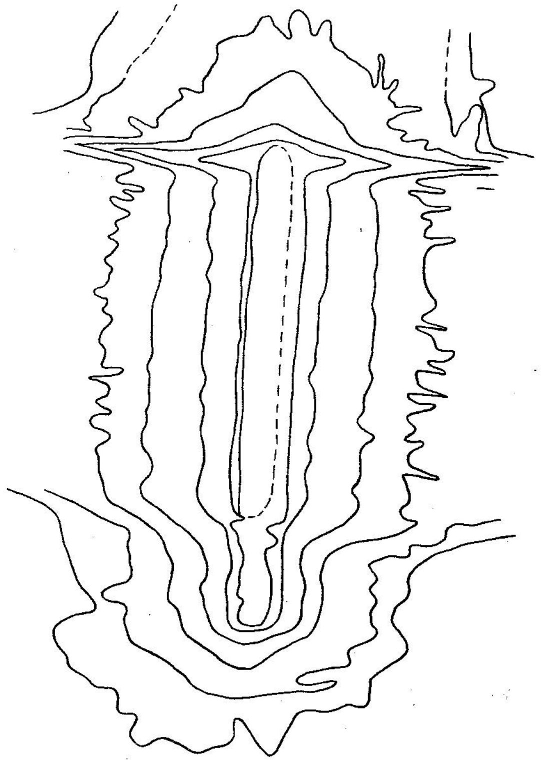

Fig. 4a.

The equidensities may be obtained by several procedures [4—8]: a) by picture photometring point by point using a micro-photometer; b) using a micro-photometer we perform the picture measurement and by special electronic processing the equidensities are then displayed on the television picture tube; c) by

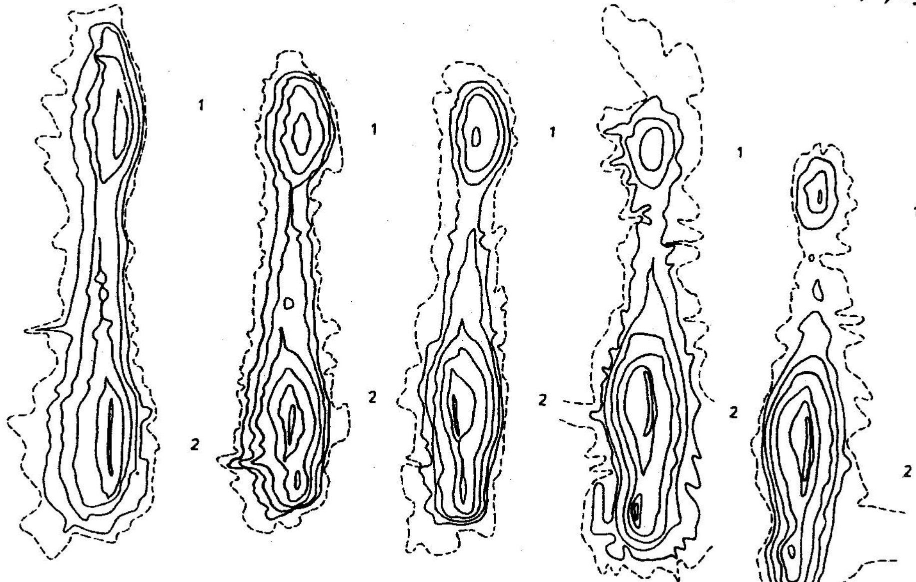

Fig. 4b.

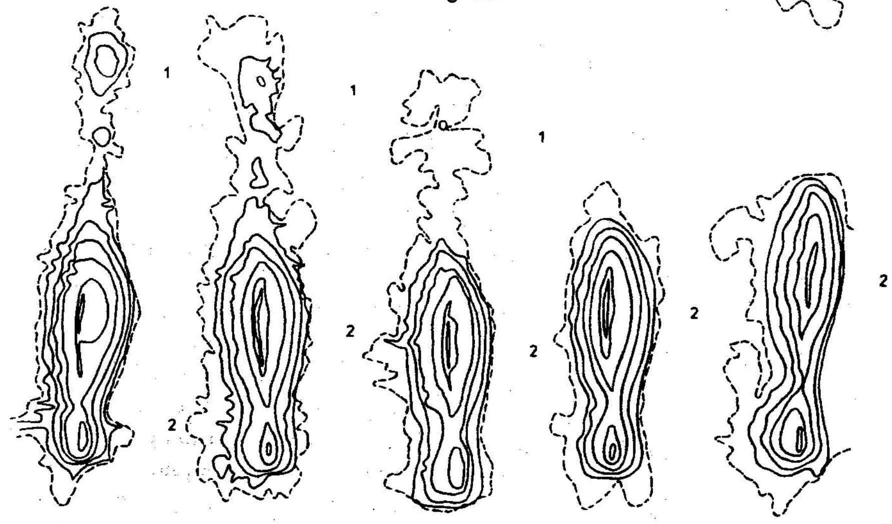

Fig. 4c.

the micro-photometer suitably connected with a recorder and an analog computer the pictures are measured and the results are recorded; b) the photographing procedure uses the Sabattier effect.

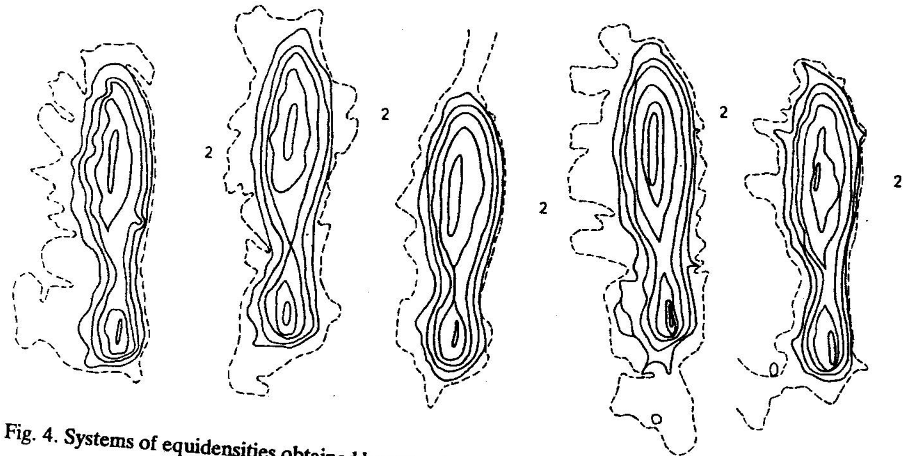

Fig. 4. Systems of equidensities obtained by procedures c). Optical density $S=0$; 0.097; 0.222; 0.398; 0.699; 1.000; 1.125. Time difference between pictures is 3.33×10^{-4} s.

Breakdown pictures (power 84 W, high frequency voltage 1060 V, d.c. voltage + 5 kV, distance of electrodes 5 cm) with the help of a high speed camera were subjected to an equidensitometrical analysis and the approaches c) and d) considered here were compared. In Fig. 2 there are illustrated systems of equidensities obtained by photography. The time difference between the pictures is 3.33×10^{-4} s, thus, the time interval bling 1.1×10^{-2}s. The next configuration in this figure represents the real breakdown after the decay of the plasmoid (1) within the region beneath the upper electrode has taken place. Simultaneously, there is formed close to the point electrode another plasmoid (2), moving towards the upper electrode to decay again. The decay of both plasmoids is truly reproduced by the configurations of equidensities and may be interpreted by the time dependence of the optical density maximum value of the pictures of plasmoids (1) and (2), Fig. 3. The maximum values were evaluated from measurements mentioned in c), Fig. 4. The lifetime of plasmoids (1) is 3×10^{-3}s and that of plasmoid (2) is 10^{-2}s. The first configuration of equidensities in Fig. 2 illustrates the deformation of the high frequency discharge before the breakdown. There can also be seen an evident difference between the real breakdown and the following plasma decay.

Taking into account the above we may conclude that the equidensitometrical analysis might not only help to evaluate the data of the discharge geometry and the time dependence, but also those of temperature, at least only approximately.

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