THE FIELD STRENGTH AND ELECTRON DENSITY CALCULATIONS FOR THE CORONA PULSES

M. Laan, H. Korge, K. Kudu

To cite this version:

M. Laan, H. Korge, K. Kudu. THE FIELD STRENGTH AND ELECTRON DENSITY CALCULATIONS FOR THE CORONA PULSES. Journal de Physique Colloques, 1979, 40 (C7), pp.C7-351-C7-352. <10.1051/jphyscol:19797173>. <jpa-00219150>

HAL Id: jpa-00219150
https://hal.archives-ouvertes.fr/jpa-00219150
Submitted on 1 Jan 1979

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
THE FIELD STRENGTH AND ELECTRON DENSITY CALCULATIONS FOR THE CORONA PULSES

M. Laan, H. Korge and K. Kudu.

Tartu State University, Department of Physics, Tartu, Estonian S.S.R.

Introduction. In our previous paper [1] the spatio-temporal development of luminosity in Trichel pulses and pre-onset streamers of D.C. coronas was determined. The measurements were carried out in the point-to-plane gap in laboratory air. In this paper we are going to report about an attempt of the calculation of the main characteristics of the corona pulses on the basis of luminosity distribution measurements [1]. Such calculations for gas discharge in nitrogen in the homogeneous gap were made for the first time by Doran [2]. In our calculations the same procedure was used for the air. We supposed only two processes—ionization, and attachment—are active within the volume element under observation and that the photomultiplier current is a linear function of light intensity. So we were able to evaluate the spatio-temporal distribution of the reduced field strength (E/p), the rate of change in the number of electrons (dne/dt=d(p+ - n+)/dt), and the line density of electrons (ne).

On the basis of the curves E/p(x) a rough approximation of the spatio-temporal distribution of the charged particles concentration (N+ - N- - Ne) was made, using the one dimensional Poisson equation.

Trichel pulse. The calculated field distribution differs considerably from the Laplacian one. It is possible to discern two stages in the Trichel pulse development (A and B, Fig. 1). During stage A the formation of the characteristic visible regions of the discharge pulse—the negative glow, Faraday's dark space and the positive column—takes place. At the moment t = 2 ns the high field region is concentrated at a distance of x = 0.25 mm from the point. In this region the rate of change in the number of electrons and ions has a maximum. As a result, the positive space charge maximum moves towards the point. This process stops when the space charge concentration maximum has shifted to x ≈ 0.05 mm. During stage A attachment is not active and the reduction in field strength is due to the intensive generation of electrons and positive ions. During stage B, dne/dt reduces quickly by the moment t = 20 ns attachment becomes dominant.

A streamer develops from a burst pulse when the number of electrons near the point exceeds 5 \times 10^6. In this case the condition of plasma existence is fulfilled near the point electrode tip. By the moment t = 14.5 ns counted from the detectable luminosity level.

Fig. 1. Trichel pulse. Spatio-temporal distribution of the E/p, dne/dt, ne and (N+ - N- - Ne), the parameters expressing time counted from the beginning of the detectable luminosity level.
able beginning typical distributions of the $E/p$, $dn_e/dt$, $n_e$ and $(N_+ - N_- - N_e)$ have become established (Fig. 2). The characteristic regions $I - V$ of a streamer have been indicated for the moment $t = 18$ ns (dotted curves).

In region I avalanches arise due to photo-ionisation. Region II of intensive ionisation has a considerable spatial extent. The increasing $n_e$ compensates the positive space charge and produces a decrease in $E/p$. Supposing the streamer channel diameter is 50 μm, the electron concentration is of the order of $10^{14}$ cm$^{-3}$, which about three times exceeds the order of $(N_+ - N_- - N_e)$ for this region. Consequently, the discharge channel is quasi-neutral. In region III a decrease in field strength produces an increase of attachment and hence causes a decrease in $dn_e/dt$. In region IV the electron drift causes the accumulation of a negative space charge. Between the positive space charge near the point (region V) and the negative space charge the electrical field strength enhances and therefore $dn_e/dt$ and $n_e$ increase.

The results obtained for the pre-onset streamer in the best way correspond to the model of the streamer developed by Phelps [3]. The accuracy of calculations significantly decreases for $x > 2$ mm because of the considerable deviation of the streamer branches from the discharge gap axis. In the zone near the point the distribution $(N_+ - N_- - N_e)$ may be invalid as the discharge diameter changes sharply.

To verify the validity of our assumptions made above, the current of a Trichel pulse and of a pre-onset streamer was calculated in two different ways (Fig. 3) and was compared with the measured current. A more detailed analysis of this work is given in [4].

References:

Fig. 2. Pre-onset streamer. Follow the text and Fig. 1.

Fig. 3. Measured (solid curves) and calculated (o and x) current pulses of a Trichel pulse (a) and of a pre-onset streamer (b).