

Experiments on streamer interactions

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A streamer is a rapidly extending discharge channel that can appear when a high voltage is applied to any ionizable medium. Streamers precede phenomena like sparks, leaders and lightning. The main difference is that streamers do not significantly increase the gas temperature; they are rather governed by impact ionization and space charge effects [1].

We have investigated 1. the interactions between two streamers that emerge from two needle electrodes at a short distance, and 2. the distribution of branching angles of a streamer tree between point to plane electrodes.

All experiments have been performed in ambient air at atmospheric and lower pressures on positive streamers. The streamers have been generated by means of a capacitor that is charged negatively with a DC power supply and then discharged by a fast switch [2]. In the presented measurements, a positive voltage of 47 kV with a rise-time of about 30 ns is applied to the point(s). The distance from point(s) to plate is 14 cm.

1. The initial interaction between two streamers has been measured by imaging streamers that propagate between plane parallel electrodes with two parallel anode needles inserted into the anode plate. As streamer during their early evolution scale very well with pressure [1,3], we measure the distance d between the needles in units of [mm·bar]. For low pressures p and small tip separations d , e.g., for $p \cdot d = 0.1$ mm·bar, there is only one large streamer visible that emerges from the anode needles, while for higher pressures and/or larger tip separations, e.g., for 1.8 mm·bar, two clearly separate streamer channels emerge from the two needles. Depending on pressure, these channels themselves can branch. We have measured the interaction between the two initial channels as function of pressure and tip separation distance.

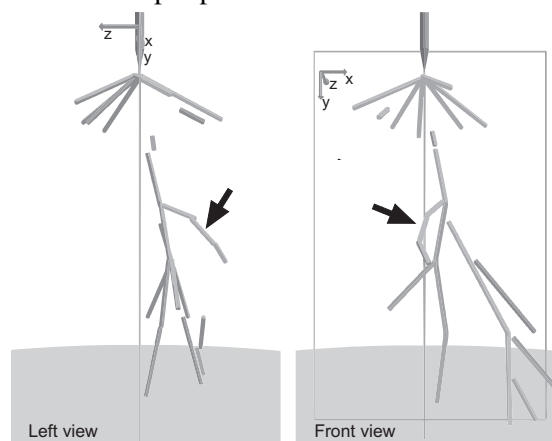


Fig. 1 Orthogonal views of a 3D reconstruction of a streamer discharge. Note the section marked with the black arrow. In the front view (and the original images) this section seems to reconnect with another section, while the left view clearly contradicts this (from [4]).

2. In a second experiment we have generated multiply branched streamer trees out of a single needle electrode in point to plane geometry, and we have measured the angles between branches. To do this correctly we need more than just a 2D image of a streamer discharge, since it is impossible to know if a certain branching event occurs parallel or (nearly) perpendicular to our camera image. Therefore we have applied a stereo photography method that enables us to reconstruct the streamer discharge in 3D (see figure 1 for such a reconstruction) [4].

From these reconstructions we have evaluated branching angles and plotted them in figure 2 as function of $p*d$, where p is the pressure and d is the vertical distance between the branching event and the anode tip. We also have included a linear fit into figure 2. However, it is not clear whether the linear decrease is significant due to the wide distribution of branching angles.

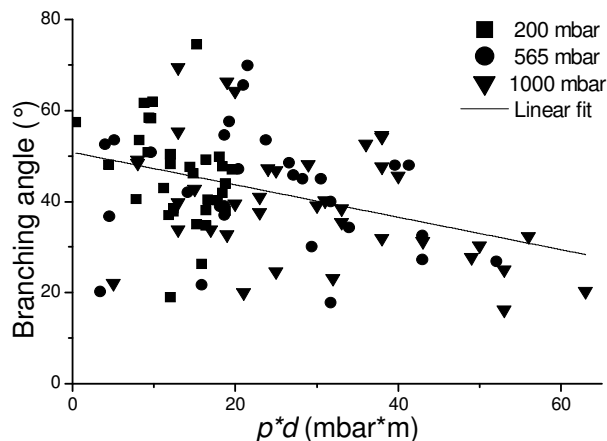


Fig. 2 Measured branching angles as function $p*d$, where p is the pressure and d is the vertical distance between the branching event and the anode tip (from [4]).

Besides branching angles, we can learn a lot more from the 3D reconstructions. For example, we can investigate whether streamer channels do reconnect. An example of an apparent reconnection can be seen in figure 1, while in other cases reported in [2] we believe reconnection (of a different type) to be real, but that is up to future stereographic confirmation.

References

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