Physics of streamer discharges and lessons learned from the study of discharges in laboratories for the study of atmospheric electrical discharges

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The objective of this talk is first to present a review on basics physics of streamer discharges in air at atmospheric ground pressure based on experimental and numerical studies. Current challenges for applications and motivations of current studies in laboratory experiments will be discussed. Second, lessons learned from the study of discharges in laboratories for the study of atmospheric electrical discharges will be presented.

1. Introduction

Since a few years, there are numerous interactions between researchers working on large-scale high altitude discharges and researchers working on discharges in air at atmospheric ground pressure ignited by different types of voltage generators between electrodes separated of a few millimetres to a few centimetres. To understand each other between different scientific communities, it is very important to use the same words and concepts to define the same physical phenomena. In this talk, first, a review of basics physics of streamer discharges as defined for laboratory experiments at atmospheric ground pressure will be presented. Second, lessons learned from the study of discharges in laboratories for the study of atmospheric electrical discharges will be discussed.

2. Physics of streamer discharges

Based on a review of experimental and numerical studies, main characteristics of positive and negative streamer discharges in air at atmospheric ground pressure will be presented. First, ignition of streamer discharges will be discussed and the limitation of the classical Townsend theory for filamentary discharges will be put forward. Then the Meek's criterion will be discussed [1]. Second, key processes for the discharge propagation in the interelectrode gap will be presented. In particular the role of photoionization versus gas preionization will be discussed.

Then, the different strategies for streamer discharge modelling will be presented. For the widely used fluid model, a brief review of numerical schemes will be presented. The influence of the accuracy of transport coefficients and source terms for atmospheric pressure air discharges will be discussed. Finally, current challenges of experimental studies and numerical studies for various applications will be presented.

3. Lessons learned from the study of discharges in laboratories for the study of atmospheric electrical discharges

As pointed out by Pasko et al [2], some properties of atmospheric electrical discharges are similar to those of streamer discharges in laboratories taking into account the scaling of discharge properties based on gas density. This scaling will be presented and then discussed in the frame of the streamer to spark transition [3]. Then, the influence of pressure on photoionization will be presented to explain the branching of streamer discharges observed at ground pressure [4]. In recent years, numerous observations of transient luminous events have been recorded. Based on the discharge optical emission, some discharge characteristics as the peak electric field in the discharge front can be derived. This approach will be discussed with its limitations. A recent work providing a correction factor to accurately estimate the electric field in the front will be presented [5].

4. Acknowledgments

This work is the result of stimulating and rewarding collaborations with several colleagues and in particular with Pierre Ségur and his group (LAPLACE, Toulouse France), Zdenek Bonaventura (Masaryk University, Czech Republic), Sebastien Celestin, Jérémy Riousset, Ningyu Liu and Victor Pasko (PennState University, USA).

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