



## Article

# The Physical Experimental Modelling of the Formation Processes of Upward Discharges from Grounded Objects in the Artificial Thunderstorm Cell's Electric Field

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**Abstract:** The results of the physical modelling of the formation processes of upward discharges from grounded objects in the artificial thunderstorm cell's electric field are presented. We established the considerable influence of the electrode tip's radius on the pulse streamer corona stem's parameters and, subsequently, on the probability of the transformation of the impulse streamer corona first flash's stem into a first stage of upward leader. We determined the diapason of the optimal tip radii for a lightning rod or lightning conductor, which allows for the most probable formation of the first impulse streamer corona, with the parameters providing the best conditions for the upward leader's start, the purpose of which is the lowering of the probability of lightning striking the object under protection. A considerable difference between the electrical characteristics of the first impulse corona flash with and without the streamer-leader transition was established. It was shown that the amplitude of the streamer corona flash current impulse is considerable, but not the main defining factor of the streamer-leader transition. It is established that the charge value of the streamer corona first flash is not a threshold requirement for the formation of the upward leader from a ground object, but only defines the probability of the successful upward leader formation. Based on the analysis of the experimental data received, we suggest that there is a dependency between the probability of upward positive leader formation from the grounded objects and the charge value of the first pulse streamer corona flash for the rod (centered) and rope (elongated) lightning conductors and objects in the electric field of the thundercloud and downward lightning leader. The obtained results can be used for mathematical modelling of the formation processes of upward discharges from grounded objects in the artificial thunderstorm's electric field, as in a natural thunderstorm situation.

**Keywords:** lightning; upward discharges; artificial thunderstorm cell; physical simulation; first impulse streamer corona flash; stem; streamer-leader transition; model lightning rod and lightning conductor; probabilistic criterium



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## 1. Introduction

Despite the obvious successes in solving lightning protection problems and researching lightning physics, presently we are still facing some considerable and relevant fundamental and practical problems in the physics of lightning formation, lightning striking grounded objects, and ensuring their reliable lightning protection [1–5]. The reason for this is the increasing technical functionality and complexity of the grounded objects, which, in turn, leads to increased requirements for their lightning protection systems.

More specifically, the research is focused on the formation processes of upward discharges from grounded objects and lightning rods (conductors), which generally determine the probability of lightning striking a grounded object and the efficacy of its lightning protection, as well as how the regulatory documents and calculation methods used in the lightning protection industry can be perfected [1,2,4–9]. Modelling of upward leader

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