



## Observation of X-rays from long laboratory negative discharge in STP air

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Pulses of x-rays emitted by lightning are one of the most intriguing among unsolved problem in physics of lightning. They have been detected from both - natural and rocket-triggered lightning. In natural lightning x-rays were detected during stepped leader process and later were associated with a single step. In triggered lightning x-rays were found to be originated from a tip of a dart leader that also possesses stepping propagation mechanism. Therefore, stepping mechanism is the key to understanding the x-ray pulses generated by lightning. Unfortunately, leader stepping mechanism itself is far from well understood.

Negative long laboratory discharges also develop through a formation of a space stem/leader and they also generate bursts of x-ray radiation. In this study we investigate the development of a long negative laboratory spark in particular focusing on its x-ray emission.

A 2 MV Marx generator delivers high-voltage standard lightning pulse with 1.2/50 microsec rise/fall time to a spark gap with conical electrodes. The distance between cone tips was varied between 1 m and 1.75 m. An upper voltage limit is set to about 1 MV level. The voltage is measured by capacitive high-voltage divider. Two Pearson 7427 current probes determine the currents through high-voltage and grounded electrodes. Two LaBr3 scintillator detectors were mounted in EMC-cabinets and recorded the x-rays. Picos4 Stanford Optics camera with intensified CCD is placed in 4 m distance from the spark gap and directed perpendicular to the spark plane. The camera allows us to make ns-fast images of pre-breakdown phenomena in controllable time.

We discovered new details of space stem/leader formation and development in long laboratory sparks. The connection moment of positive part of the space stem/leader to negative high-voltage is accompanied by intense x-ray emission. Taking into account our previous study on positive discharge, we conclude that encounter between positive and negative streamers is the most likely mechanism responsible for the x-rays.