Corona initiated from grounded objects under thunderstorm conditions and its influence on lightning attachment

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Corona discharge occurs in the gaps with strongly non-uniform electric field. Corona discharges have been much studied on a laboratory scale and have been used in many technologies. Coronae referred to also as point discharges are often initiated from the tips of trees, bushes, grass and other sharp ground objects under thunderstorm conditions. This happens due to atmospheric electric field intensification at these "points'. Such thunderstorm coronae are most often positive because the main lower cloud charge is generally negative.

For the last decade, author's studies have shown that a thunderstorm corona initiated from the top of a high grounded structure can affect strongly the initiation of an upward lightning discharge from the high structure and that of an upward connecting leader that is formed in the electric field of an approaching downward lightning leader. The last process predetermines mostly lightning strike to the given structure since both of the leaders develop to meet each other.

Stationary coronae filling the whole space between the electrodes have attracted much more attention than non-stationary ones since the ion front generally bridges laboratory gaps very fast. The thunderstorm corona is always non-stationary since the ion front does not reach the opposite electrode removed to "infinity". An approximate theory of a non-stationary corona and a computer model to simulate numerically the corona properties in atmospheric electric fields have been developed. It was done for solitary structures as well as for a number of closely spaced objects when their individual coronae interact with each other. Properties of the non-stationary corona with the moving ion front differ essentially from those of the stationary one. The discharge current depends not only on the voltage but on the rate of its rise as well, current can be much larger than that under stationary conditions at the same voltage and can vary in time even at constant voltage etc.

Initiation and development of a leader from the top of a high structure are considered under thunderstorm conditions. A viable leader can develop if (i) a streamer flash is initiated from the top, (ii) it is followed by the leader initiation and (iii) the leader propagates steadily. It is shown that it is more difficult to satisfy all these requirements in the presence of the corona. In particular, the streamer flash takes place when the corona current from the top of the "electrode" exceeds some threshold that has been determined analytically and numerically. The calculated radius of downward lightning attraction to structures and number of upward and downward lightning strikes to them are presented as a function of the structure height. It is explained why very high objects such as the Ostankino TV Tower in Moscow initiate upward lightning discharges much more often than are struck by downward ones.

The yet poorly understood mechanism of lightning attachment to high structures and possibilities to control the number of lightning strikes to grounded objects when affecting the corona process are discussed. The effect of wind on the corona discharge is considered as well as the formation of an extended plane ion layer above the earth surface covered with vegetation. Such corona space charge layers reach hundreds of meters in thickness under thunderstorm conditions. They participate in the global charge transformations in the atmosphere.