LARGE SCALE MODELING OF BLUE JETS AND BLUE STARTERS

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Blue jets develop upwards from cloud tops to terminal altitudes of about 40 km at speeds of the order 100 km/s and are characterized by a blue conical shape [1-3]. Blue starters are distinguished from blue jets by a much lower terminal altitude. They protrude upward from the cloud top (17-18 km) to a maximum 25.5 km in altitude [4]. Recently, the first video recording of a blue jet, which electrically connected a thundercloud with the lower ledge of the Earth's ionosphere, has been reported [5]. This video recording provides the most detailed evidence presented to date of internal streamer structure of blue jets predicted in [6].

Blue jets and blue starters have been captured by black and white and color video cameras, allowing to make some important suggestions about optical bands responsible for the observed blue color [1]. The evidence from color TV that suggested that the blue light must have an ionized 1st negative N2+ component has been presented in [2]. The first conclusive evidence of 427.8 nm (1st negative N2+) emission in blue starters has been recently reported in [3]. The authors of [3] also analyzed color TV frames associated with blue starters and concluded that the combined red and green channel intensity constituted 7% of the total blue channel intensity.

We report here results from a three-dimensional fractal model [7], which is based on a phenomenological probabilistic approach to modeling of streamer coronas proposed in [8]. The model simulates the propagation of branching streamer channels constituting blue jets and starters as a three dimensional growth of fractal trees in a self-consistent electric field created by thundercloud charges. The model results indicate that blue jets and starters can be formed by a fast (~1 sec) accumulation of 110-150 C of positive thundercloud charge distributed in a volume with effective radius 3 km near the cloud top at 15 km. The obtained results closely resemble characteristics of blue jets and blue starters [1-5] in terms of their altitude extents, transverse dimensions and conical structure, and support the suggestion of Wescott et al [4] that blue starters are related to the initial phases of blue jets.

The fractal model allows accurate determination of the macroscopic electric fields in regions of space occupied by streamers. Our results indicate that for a variety of input parameters these fields are very close (within several %) to the minimum electric field required for propagation of positive streamers in air [7 and references therein] and generally are not sufficient to excite any observable optical emissions. Our conclusion therefore is that the observed optical luminosity in blue jets and starters comes from large electric fields existing in narrow regions of space around tips of small-scale corona streamers constituting them. We present comparisons of a spectroscopic model results with laboratory experiments on emission spectroscopy of corona discharges in air at different pressures and with observations [1-5], which support this conclusion. The model results indicate that the combined red and green video channel intensity constitutes ~7% of the total blue channel intensity, in good agreement with [3]. The model results also indicate that the 2nd positive of N2 and 1st negative N2+ bands are the dominant contributors to the observed blue emissions and their relative contributions are ~80% and ~20%, respectively, at the base of blue jet and ~60% and ~40% at altitude 40 km.

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