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Initiation of Positive Streamer Corona in Low Thundercloud Fields

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1. Extended Abstract

Initiation of lightning leaders in low thundercloud fields remains one of the unsolved problems in lightning discharge physics [1, and references therein]. One of the minimum conditions required for formation of a leader channel is initiation of streamer corona, that likely involves electric field amplification on large precipitation particles (radius >6 mm) [e.g., 2]. Babich et al. [3] has recently reported quantitative results indicating that the electron avalanche to streamer transition is possible around relatively small particles (~0.5-1.5 mm) when they carry a net charge on the order of 100 to 400 pC, with specific minimum values depending on geometrical properties of particles and their overall size (see Table 1 in [3]). The existence of significant charges on precipitation particles, up to 400 pC, is supported by measurements from balloons [e.g., 4]. We note that electric field magnitudes formed on the surface of the particles discussed in [3] are predominantly controlled by their net charge and exceed those required for initiation of ion corona that would tend to reduce the field by spreading the charge to a larger volume around the particle. In this work we report quantitative results on possible scenarios when avalanche to streamer transition is possible in a system of two precipitation particles passing in close vicinity of each other, but not carrying a significant net charge. We demonstrate that for realistic particle dimensions the avalanche to streamer transition is possible in local electric field just slightly above the minimum field required for propagation of positive streamers in air (i.e., ~4.4 kV/cm at ground level or ~1.76 kV/cm at 0.4 atm pressure considered in [3]). The considered scenario resembles conditions of well-conducting particles discussed in [5] and [1].

2. References

1. Mazur, V., C. D. Taylor, and D. A. Petersen, "Simulating electrodeless discharge from a hydrometeor array", J. Geophys. Res., 120, 20, October 2015, pp. 10879-10889, doi:10.1002/2015JD023466.

2. Cooray, V., "On the minimum length of leader channel and the minimum volume of space charge concentration necessary to initiate lightning flashes in thunderclouds", J. Atmos. Sol. Terr. Phys., 136, Part A, December 2015, pp. 39-45, doi: http://dx.doi.org/10.1016/j.jastp.2015.09.008

3. Babich, L. P., E. I. Bochkov, I. M. Kutsyk, T. Neubert, and O. Chanrion, "Positive streamer initiation from raindrops in thundercloud fields", J. Geophys. Res., 121, 11, June 2016, pp. 6393-6403, doi:10.1002/2016JD024901.

4. Marshall, T. C., and W. P. Winn, "Measurements of charged precipitation in a New Mexico thunderstorm: lower positive charge centers", J. Geophys. Res., 87, NC9, August 1982, pp. 7141-7157, doi:10.1029/JC087iC09p07141.

5. Nguyen, M. D., and S. Michnowski, "On the initiation of lightning discharge in a cloud 2. The lightning initiation on precipitation particles", J. Geophys. Res., 101, D21, November 1996, pp. 26675-26680, doi:10.1029/96JD02338.