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Avalanche-to-streamer transition near hydrometeors in thunderstorms

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In the early phase of lightning initiation, streamers must form near water droplets and or ice crystals, collectively called hydrometeors, as it is generally believed that the electric fields in a thunderstorm are below classical breakdown [1]. The hydrometeors, due to their dielectric property, electrically polarize and will enhance the thunderstorm electric field in localized areas just outside the surface, potentially above breakdown.

Available electrons, from for example a cosmic ray event, are drawn towards the positive side of the polarized hydrometeor. Some electrons reach the localized area above breakdown, while oxygen molecules have absorbed others. In the area above breakdown electrons begin to multiply in number, creating electron avalanches towards the surface, leaving positive ions behind. This results in a charge separation, which potentially can initiate a positive streamer. The final outcome however strongly depends on several parameters, such as the strength of the thunderstorm electric field, the size and shape of the hydrometeor and the initial amount of electrons.

In our letter [1] we introduced a dimensionless quantity M that we call the Meek number, based on the historical and well-used Reather-Meek criterion [2], as a measure of how likely it is to create an avalanche-to-streamer transition near a hydrometeor. Results from simulations showed that streamers can start in a field of only 15% of breakdown from large elongated shaped hydrometeors.

Now we extended and generalized our method to arbitrary shaped hydrometeors and we take into account that potentially several electrons can reach the area above breakdown. Due to these effects we can predict smaller hydrometeors to be able to start streamers.

We will present the latest results.

[1] Dubinova, A., Rutjes, C., Ebert, U., Buitink, S., Scholten, O., & Trinh, G. T. N. (2015). Prediction of lightning inception by large ice particles and extensive air showers. Physical review letters, 115(1), 015002.

[2] Meek, J. M. (1940). A theory of spark discharge. Physical Review, 57(8), 722.