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Modelling Discharge Inception in Thunderstorms

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The electric fields in thunderstorms can exceed the breakdown value locally near hydrometeors. But are fields high enough and the regions large enough to initiate a streamer discharge? And where would a sufficient density of free electrons come from to start the discharge in the humid air that rapidly binds electrons in water-clusters?

At the AGU last December we presented our results with the focus on the first question: the streamer initiation, simulated by our 2D cylindrical symmetric streamer fluid code, that now can include dielectric bodies. We use the frequency dependent dielectric permittivity of ice, accounting for the fact that ice can not polarise instantaneously. This important fact makes it harder to develop a streamer. For the second question we showed that an extensive air shower can produce the needed electron density to start a discharge and that relativistic breakdown is not needed.

But what are the 'optimal' parameters in question to be expected in a thunderstorm? Which hydrometeor sizes and shapes work and which do not? How (in)homogeneous is the electron density produced by the extensive air shower? And how much will this influence the streamer initiation?

The problem is very multi-scale; there are 4 orders of magnitude in time, 8 orders of magnitude in length and 16 orders of magnitude in energy; from high energetic cosmic particles entering the atmosphere down to streamer development near a hydrometeor.

We have now one-to-one connected the high energy domain, usually » 0.5 MeV, of the extensive air shower, down to thermal ($\sim$0.03 eV) energies. We simulate the extensive air showers in full detail with CORSIKA [1] and than extend only the electromagnetic part, with use of EGS5 [2] and our group developed codes [3].

We will present the (in)homogeneity of the produced free electron density by extensive air showers and it's influence on the streamer initiation problem.

[1] https://web.ikp.kit.edu/corsika/
[2] http://rcwww.kek.jp/research/egs/egs5.html
[3] http://cwimd.nl