Radio Frequency Emission Spectrum of Colliding Streamers

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Streamers are filamentary, plasma discharge waves that occur in electrical discharges in laboratories and in atmospheric electrical phenomena such as lightning and sprites. Electrical breakdown of air, often beginning with streamers, is an intrinsic part of atmospheric electrical discharges and it is known to emit radiation in the radio frequency (RF) band. The highest observed electric field in a thundercloud is much lower than the threshold field needed to initiate electrical breakdown; and streamer initiation and propagation in sub-breakdown ambient fields has been an actively-pursued research subject. The initiation and propagation process of lightning is also known to involve oppositely propagating streamers. It is known that propagating streamers at lightning altitudes can emit electromagnetic radiation with frequencies up to the very high frequency band (Shi et al., JGR, 121(12), 7284, 2016) whereas colliding streamers can emit radiation in the ultra high frequency band (Luque, JGR, Atmos., 122, 10,497, 2017; Shi et al., GRL, in review), as well as higher frequencies (Shi et al., in review). The emission spectrum from colliding streamers depends on three parameters: the ambient electric field, the total length of propagation, and the size of the streamer head. Quantifying how the streamer RF emission spectrum changes with these parameters will enable a better understanding of the lightning RF emissions.

In this talk, we present the analysis of the electromagnetic emission spectra from streamer collision simulations of varying propagation lengths, ambient electric fields and streamer head radii. We also show the emission spectrum results from streamer collisions in sub-breakdown ambient fields, which may help improve our understanding of the lightning initiation process.