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The Role of Streamers in the Initiation of Electrical Discharges in the Earth's Atmosphere

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Streamers are filamentary plasmas that are created by self-propagating ionization waves. They are precursors of spark discharges in laboratory experiments, and are also key components of electrical discharges in the earth's atmosphere, such as lightning, jets and sprites. Despite hundreds of years of research, how lightning originates inside thunderclouds is poorly understood. The problem is that the measured thunderstorm electric field is well below the threshold value to start electrical discharges. A hypothesis for lightning initiation is that thundercloud hydrometeors (water droplets or ice particles) can enhance thunderstorm electric field sufficiently to initiate streamers, which then lead to initiation of lightning leaders. Although streamer discharges can be investigated through laboratory experiments in a controlled manner, their properties in unconfined systems like a thunderstorm are not well studied. About thirty years, high-altitude discharges now called jets and sprites were discovered, and it has been found that streamers are the building blocks of those massive discharges. The research studies on jets and sprites have shed light on the physics of streamer initiation and propagation in a large, electrodeless environment. In this talk, we discuss our recent observational and modeling work on understanding the initiation of lightning, jets and sprites. The discussion is focused on the role played by streamers in the initiation of those phenomena.