

## Investigation of Streamer Initiation in Sprite-Halo Events

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Sprites are spectacular optical emissions in the mesosphere induced by transient lightning electric fields above thunderstorms. These luminous gas discharges often exhibit a brief descending high-altitude diffuse glow in the shape of a pancake with diameters up to  $\sim 80$  km near  $\sim 75$  km altitude, referred to as a sprite halo, that sometimes is accompanied by development of fine-structured filaments with diameters up to several hundred meters in the altitude range of  $\sim 40$  to  $\sim 90$  km, commonly referred to as sprite streamers. Since the first video documentation [Franz *et al.*, Science, 249, 48, 1990], sprites have attracted extensive research interest in the last two decades, primarily due to their potential as natural resources for the study of streamer physics, their potential impact on the chemistry in the upper atmosphere, and their ability to perturb the subionospheric radio signals [Qin *J.*, PhD Dissertation, Penn State, 2013, and references therein]. However, up to date, how these filamentary plasmas are initiated in the lower ionosphere remains a subject of active research and existing theories differ fundamentally from each other [Luque and Ebert, Nature Geoscience, 2, 757, 2009; Qin *et al.*, JGR, 116, A06305, 2011]. To better understand the initiation mechanism of sprite streamers, in the present work, a plasma fluid model developed previously by Qin *et al.* [JGR, 118, 2623, 2013] is used to investigate the initiation of sprite streamers during the development of a sprite halo. High-speed video observations of sprites are also studied in a comparison manner. The reported results suggest that the presence of plasma inhomogeneities in the lower ionosphere is a necessary condition to initiation sprite streamers, in agreement with the recently proposed sprite theory of Qin *et al.* [2011]. The polarization of the plasma inhomogeneities produces strong space charge field in a localized region, which greatly facilitates the initiation of sprite streamers. The presented results once again reiterate the idea that the strength of the lightning induced electric field produced by a relatively large charge moment change is a necessary but not sufficient factor for initiation of sprite streamers [Lang *et al.*, JGR, 116, A10306, 2011] and the presence of inhomogeneities is an important factor, especially for low charge moment changes.