On the speed of sprite initiation

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Abstract

Sprites are composed of individual streamer discharges (e.g., Pasko, 2010) which split into streamer tips (McHarg et al., 2010) with diameters ~50-100 m at ~60-80 km height (Kanmae et al., 2012). The sprite luminosity coincides in time and space with extremely low frequency electromagnetic radiation <3 kHz in excellent agreement with theory (Cummer and Fullekrug, 2001). This theory is based on current flowing in the body of sprites at ~70-80 km height associated with large streamer densities (Pasko et al., 1998). This newly recognized physical mechanism also results in low frequency (~30-300 kHz) electromagnetic radiation emanating from sprite streamers near ~40 km height in the stratosphere, albeit with very small magnetic fields from a single streamer (Qin et al., 2012). The presence of this predicted radiation was promptly confirmed by low frequency radio noise measurements during dancing sprites with a very sensitive radio receiver (Fullekrug et al., 2013). Specifically, it was found that the sprite luminosity coincides with sudden enhancements of the radio noise. These initial observations are extended here with a more detailed analysis to compare the rise time of the lightning electromagnetic field with the rise time of the sprite luminosity. The rise time of the lightning electromagnetic field is measured with a radio receiver recording at 1 MHz. For a direct comparison, the rise time of the sprite luminosity is measured by recordings of the second positive group from molecular nitrogen at wavelengths ~334-346 nm with a photosensor at 1 us resolution. The observed rise times are compared with each other to determine the speed of sprite initiation originating from the forcing by lightning electromagnetic fields.

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